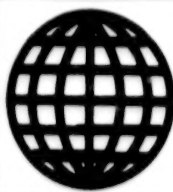


JPRS-UST-94-016

5 AUGUST 1994



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JPRS Report

Science & Technology

Central Eurasia : ALTERNATE ENERGY

SCIENCE & TECHNOLOGY
CENTRAL EURASIA
ALTERNATE ENERGY
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Stabilization Factor

947F0160A Kiev URYADOVYY KURYER in Ukrainian No 9 June, 1994 p 4

[Article by Georgiy Antypovych]

[Text] "Problems and Reserves for Energy Conservation as Economy Stabilization Factor" was the theme of a practical scientific conference organized and run by the Poltava Oblast State Administration. There was a gratifying fact in President of Ukraine Representative's Mykola Zaludyaka opening address: in April the output of Poltava oblast industrial enterprises was almost 20 percent higher than in the preceding month. After a prolonged recession this was a hope-giving news. But increasing production volume is directly related to the problem of energy conservation. According to the speaker, General Economy and Market Administration Chief Volodymyr Gryshko, the share of energy carriers in product cost has sharply increased lately and now equals 25 to 30 percent. This leads to high product prices so the products lose competitiveness in the domestic market as well as in CIS markets.

What is the way out of the situation? Of course it is necessary to use energy resources as rationally as possible, launch an offensive against squandering them and accomplish structural rebuilding of production. And, said conference participants in their speeches, there are quite a few opportunities to do this.

Practical implementation of the conversation was reflected in the recommendations. In particular it is envisaged to create an expert council on problems of development and implementation of energy saving technologies under the auspices of the oblast State administration, reduce consumption of energy carriers per unit of production in 1994-1995 by 15 to 20 percent, continue industry diversification, use nontraditional sources of thermal energy by implementing biogas and solar installations, study the feasibility of using rape oil as ecologically clean fuel for internal combustion engines, reduce as much as possible industrial scrap by utilizing it, etc.

From Words to Actions

947F0160B Kiev ZELENYY SVIT in Ukrainian No 8, 1994 June p 5

[Article by O. Lystopad]

[Text] A year and a half ago this newspaper wrote about "Attika-West", a wind-power project for Ukraine. The main obstacle for implementation of the project was Government's reluctance to provide financial guarantees to potential investors. There are no guarantees today either but SP [joint enterprise] "Attika-West" did find a way to begin development of Ukrainian wind power industry. It has been possible to overcome the obstacle by concluding a direct agreement with VO [industrial association] Krymenergo. It is Krymenergo that is now the customer of the wind-power station, while investment will be collateralized by mortgaging the entire VO property.

The station is a complex of two thousand windmills and auxiliary equipment, total capacity 500 MW. The technology is from the USA, the labor is ours. A huge expanse for conversion. One can pay literally in 10 years with the electric power produced by the station. Incidentally, 500 MW is more than one-tenth of Crimea's energy demand. If everything goes according to the plan the project will be completed in 1996.

Meanwhile "Attika-West" is ready now to offer self-contained 30 kW wind-power units to all who want them. Interested in more details? Call the editorial office at 213-07-92.

Nontraditional Renewable Energy Sources: Status and Development Outlook

947F0170A Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 12. Dec 93 pp 9-12

[Article by E.M. Perminov, RAO of the Russian Consolidated Power System]

[Text] Today, science is promising to develop efficient uranium reprocessing methods, more advanced and effective methods of fossil fuel utilization, fusion converters, etc., yet the dynamics of our daily existence once again lead us to renewable and ecologically cleaner energy sources.

Nontraditional renewable energy sources (NVIE) are attractive not only due to their unlimited resources and environmental cleanness but also due to the principal possibility of ensuring a harmonic relationship between the society and the environment on our planet.

Assuming that each person annually consumes $60 \cdot 10^9$ J of energy which is equivalent to burning 2 tons of coal or 1.5 tons of petroleum, world energy resources consumption amounts to approximately 12 billion tons of equivalent fuel or $(3-5) \cdot 10^{12}$ J.

At the same time, solar radiation reaching the Earth's surface alone amounts to $1.5 \cdot 10^{22}$ J [1], i.e., higher by two orders of magnitude. In expert estimates, the energy of the world ocean (tides, waves, currents, and temperature and salinity gradients) amounts to more than 100 billion tons of equivalent fuel. At the same time, the energy of the Earth's depth, wind, and biomass could also be utilized (a total of $1.5 \cdot 10^{27}$ J).

Today, more than 90% of the energy being consumed is supplied by to petroleum, gas, and coal and less than 10%--by all other energy sources.

Russia possesses such resources of solar, wind, geothermal, and ocean energy resources as well as the energy of small water streams, biomass, and scattered low-potential heat of the air and water masses that in the long run, they can largely meet the demand for electric and thermal power.

Nontraditional power engineering, directly or indirectly (by saving fossil fuels) also makes it possible to lower the negative impact of the power industry on the environment. The use of nontraditional energy sources may become an important energy conservation resource in the national economy and will make it possible to reduce the consumption of scarce motor fuels in decentralized power supply zones and address urgent social issues of improving the living conditions of the population in remote and rural regions as well as facilitate prevention of environmental pollution, especially in areas with a stressed environmental situation.

The pace of nontraditional power engineering development in the world intensified significantly in recent years due to the depletion of fossil fuel reserves, constantly rising fuel prices, aggravation of environmental problems, and the need to address the issues of power supply in remote and inaccessible regions.

State programs to master nontraditional renewable energy resources have been adopted in the United States, the Federal Republic of Germany, Spain, France, Australia, Japan, and other countries. It is anticipated that their proportion in the energy balance of these countries, which today amounts to 0.1-0.5%, will increase 1-5% by 2010. According to the most optimistic forecasts, the proportion of nontraditional renewable energy resources in the 21st century may exceed 18% in a number of countries.

An analysis of the utilization capability of various renewable energy resources conversion technologies, i.e., using the energy of the ocean, water streams, and Earth heat (more than 30 technologies altogether), shows that one can expect a considerable increase in their potential utilization in the 21st century.

On the other hand, feasibility studies led to the conclusion that one should not expect a significant decrease in the cost of electric power production on the basis of nontraditional renewable energy sources, although in most cases, an improvement in the nontraditional power engineering practices and equipment should bring the economic indicators of power plants utilizing nontraditional renewable energy sources closer to the indicators of traditional power installations, i.e., large thermal, hydroelectric, and nuclear power plants (Table 1) [2].

Table 1

Energy Resource Utilization Method	Specific Capital Outlays, US\$/kW, by years		
	1990-2000	2000-2010	2010-2020
Gas turbine units (GTU)	340	325	310
Combined cycle	550	535	520
Fossil fuel power plant (TES) (l)	1,150-1,470	1,150-1,430	1,150-1,430
Fossil fuel power plant (h)	1,150-1,470	1,150-1,470	1,150-1,470
Improved fossil fuel power plants (l)	-	1,350-1,600	1,350-1,600
Improved fossil fuel power plants (h)	-	1,350-1,600	1,350-1,600
TsKS under pressure	-	1,340-1,370	1,325-1,355
TsKS at atmospheric pressure	1,370-1,400	1,370-1,400	1,360-1,400
Fuel gasification cycles	1,450-1,460	1,435-1,450	1,420-1,435
Fuel cells	-	-	1,120
Integrated gasified fuel cells	-	-	1,300
Direct coal-burning combined cycle	-	-	1,150

Energy Resource Utilization Method	Specific Capital Outlays, US\$/kW, by years		
	1990-2000	2000-2010	2010-2020
Binary Rankine cycle	-	1,500-1,770	1,500-1,770
Magnetohydrodynamics (MGD)	-	-	1,450-1,550
Nuclear power plants (AES)	1,500-2,500	1,500-2,500	1,500-2,500
Coastal-type wave power plants	-	4,800	4,800
Sea-based wave power plants	-	-	7,000
Tidal power plants	-	1,840-3,680	1,750-3,500
Thermal ocean energy utilization	-	-	11,500
High-capacity hydroelectric power plant	1,840-2,760	1,840-2,760	1,840-2,760
Low-capacity hydroelectric power plants (GES)	1,150-3,450	1,150-3,450	1,150-3,450
Conventional geothermal power plants	1,150-1,720	1,150-1,720	1,150-1,720
Binary geothermal power plants	1,440-1,720	1,440-1,720	1,440-1,720
Petrogeothermal power plants	-	1,720	1,720
Geothermal head systems	-	1,720	-
Magmatic geothermal power plants	-	-	1,720
Coastal-type wind power plants	-	1,200	1,000
Sea-based wind power plants	-	-	3,450-4,600
Thermal tower solar power plants	-	3,220	2,530
Thermal parabolic cylinder solar power plants	2,530	2,530	2,300
Solar power plants with dishes	-	2,300	1,720
Crystalline silicon photovoltaic solar power plants	-	3,450-5,170	1,720-3,450
Amorphous silicon photovoltaic solar power plants	-	3,450-5,170	1,720-3,450
Thin film photovoltaic solar power plants	-	3,450-5,170	1,720-3,450
Photovoltaic solar power plants with concentrators	-	3,450-516	1,720-3,450
Biological waste heat-utilizing plants	2,280-3,220	2,280	3,220
Biomass utilization plants	1,700-2,760	1,700-2,760	1,700-2,760

Notes: (l)--Fuel with a lower sulfur content; (h)--Fuel with a high sulfur content.

The development of the nontraditional power industry is held back by a range of engineering and economic factors and problems, i.e., shortages of equipment, its poor efficiency and high cost.

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high skill and capital intensiveness of the complicated new technologies, the low capacity of the nontraditional power plants, and in many cases, the periodic and intermittent nature of energy generation and the resulting need to duplicate the power or develop expensive storage systems.

As a result of this, today, power plants on the basis of nontraditional renewable energy sources should not, in most cases, be considered as large sources of base or peak power--they make it possible to save fossil fuels, ensure power supply to remote regions, and facilitate the solution of social problems--yet they are still not competitive with large thermal, hydroelectric, and nuclear power plants.

Successful implementation of nontraditional power plants calls for re-evaluating the concept of power engineering. In so doing, in addition to centralizing electric power and heat generation control and centralizing capacities at large power plants, it is necessary to provide for combined utilization of both traditional and nontraditional power plants, the development of decentralized power engineering, development and implementation of regional programs for wide-ranging comprehensive utilization of nontraditional renewable energy sources, and create favorable economic conditions for carrying out all stages of research and development and implementing the actual developments.

The most important tasks in the development of nontraditional power engineering are the development and assimilation of production of promising economically efficient equipment (including factory-ready modular equipment) for the following purposes:

geothermal, solar, tidal, and wind power plants and small hydroelectric power plants:

self-contained computer-aided wind, solar, and wave power plants of varying capacity and purpose:

heat pump stations; and

comprehensive computer-aided bioenergy plants.

In so doing, production of the following items must be ensured:

principally new energy converters--fuel, thermochemical and thermionic cells, Stirling engines, and semiconductor photovoltaic arrays:

small-size steam-gas and gas turbine plants:

solar concentrators on the basis of parabolic cylinders and paraboloids as well as high-efficiency solar collectors:

heat exchangers and equipment for supporting geothermal units:

thermal and electric storage devices:

principally new electrical engineering equipment and facilities for automatic control of nontraditional power industry;

new heat transfer agents; and

new materials--special steels and alloys, high-strength ceramics, glass with good optical properties, plastics, semiconductors, carbon and metal fibers, etc.

It is necessary to set up a system for erecting, servicing, and maintaining specialized complex equipment for geothermal, solar, wind, magnetohydrodynamic, and tidal power plants, manufacture equipment, adjust and operate nontraditional power engineering units and systems, support the prospecting and delivery of geothermal heat transfer agents to the users, assess the potential of the solar and wind power industry in the country, evaluate the energy potential of the ocean and small rivers, and use these estimates to catalog the potential of nontraditional renewable energy sources.

The development of nontraditional power engineering installations should be primarily aimed for the areas with appropriate nontraditional renewable energy resources in the regions not serviced by the consolidated electric power grid as well as in the areas with elevated levels of environmental pollution and zones with special environmental requirements. These primarily include the country's nature preserves and health resorts, i.e.:

the Altay mountain region and Siberia where plans call for construction of small hydroelectric power plants and wind power plants;

Kamchatka and Sakhalin oblasts which are favorable for the development of geothermal and wind power industries; and

Stavropol, Krasnodar, and Pacific maritime krais, Kabardino-Balkaria, Dagestan, and Kalmykia in which the energy of the wind, sun, small rivers, and Earth's heat can be utilized.

The use of nontraditional energy sources with a small unit capacity may be efficient in rural areas where expensive power transmission and distribution systems significantly increased the cost of centralized power supply. Consequently, the industry, including on the local scale, is facing an important task of developing the production and marketing of relatively inexpensive equipment for nontraditional resource utilization to individual, primarily rural, users (solar collectors, 50-80 Kw wind-driven electric motors, solar and wind power plants and water lifting units, small and microscopic hydroelectric power plants, biogas production units, etc.); this equipment should be easy to assemble and operate.

The geothermal, wind, and solar power plants whose construction is stipulated in forecast schedules and scientific and engineering predictions of the nontraditional power industry development to the year 2000 prepared by the RAO of the Russian consolidated power system are summarized in Table 2.

Table 2

Power plant name	Generating capacity commissioning, MW by years								Total capacity, MW
	1993	1994	1995	1996	1997	1998	1999	2000	
Geothermal Power Plants									
Mutnovskaya (Kamchatskenergo)	-	-	25	25	50	25	25	25	200
Okeanskaya (Sakhalinenergo)	-	-	6	6	6	6	6	-	30
Stavropol	-	-	15	15	-	-	-	-	3
Paizhet'skaya (retrofitting) (Kamchatskenergo)	-	6	6	-	6	-	-	-	18
Koshchevskaya (Kamchatskenergo)	-	-	-	-	-	25	25	25	100
Subtotal	-	6	38.5	32.5	62	56	56	50	151
Wind Power Plants									
Kalmytskaya (Kalmykenergo)	1	3	4	6	3	5	-	-	22
Leningrad (Lenenergo)	-	-	2	2	5	5	5	5	24
Primorskaya (Dalenergo)	-	0.5	2	5	6.5	4	5	5	30
Vikhvutskaya (Komienergo)	-	0.5	0.75	0.75	-	-	-	-	2
Morskaya (Karelienergo)	-	-	1	3	5	6	7	8	30
Makhachkala (Dagenergo)	-	-	1.5	5	3	-	-	-	10
Magadan (Magadanenergo)	-	-	1	3	5	6	10	15	40
Experimental, nontraditional power engineering base at the Chirkey'skaya hydroelectric power plant (Dagenergo)	0.25	0.5	1.5	1.75	-	-	-	-	5
Test range of the All-Russian Scientific Research Institute of Hydraulic Engineering	0.25	-	-	-	-	-	-	-	-
Subtotal	1.5	5.5	12.75	23.00	28.5	29	27	23	160
Solar									
Kislovodsk experimental plant (Stavropolenergo)	-	-	-	5	-	-	-	-	5
Kalmytskaya (Kalmykenergo)	-	-	-	10	10.5	10	10	15	55
Ussuriyskaya (Dalenergo)	-	-	-	-	10	-	-	-	10
Subtotal	-	-	0.5	10	25	10	10	15	75
Total	1.5	11.5	51.2	56.00	93.0	86	84	84.5	318.5

Successful development of nontraditional power engineering cannot proceed without the necessary scientific and experimental base, so the most important challenges facing the prospects of today's nontraditional power engineering development are to develop regional centers for testing and verifying nontraditional renewable energy source equipment and utilization methods and demonstration and pilot power plants: for solar power engineering--in the Northern Caucasus and Far East; for geothermal power engineering--in Kamchatka, Stavropol kray, Dagestan, and Kuril Islands; for tidal and wave power engineering--on the Kola Peninsula and in the Far East; for wind power engineering--in Kalmykia, Dagestan, and Pacific maritime kray; for small hydroelectric power plants--in Dagestan and Altay; and for heat pumps--on the Black Sea coast of Russia.

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At the initial nontraditional renewable energy source utilization stage, it is necessary to outline steps aimed at economic incentives and state support for the developers, manufacturing enterprises, and nontraditional renewable energy source equipment and power plant users. These steps should include state grants, a system of tax benefits, and credits on special terms for the production of solar and wind power plants, solar collectors, photovoltaic converters, heat pumps, heat exchangers, biogenerators and gas generators, etc.

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Characteristic Features of Nontraditional Power Engineering Development in Russia Under Today's Conditions

947F0170B Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 12, Dec 93 pp 12-15

[Article by B.M. Kozlov, RAO of the Russian Consolidated Power System]

[Text] Starting with approximately 1973--from the onset of the energy crisis precipitated by a sharp increase in petroleum prices--world economy began considering accelerated development of alternative energy sources which substitute organic fossil fuels. Among these, nuclear power and hydroelectric power play a prominent role. In addition, interest in various types of renewable energy resources--solar and geothermal energy, wind and small river energy, and the energy contained in various organic wastes--arose. During approximately 20 years, almost all developed countries formulated special power engineering development programs based on these types of energy resources. Today, one can confidently state that nontraditional power engineering has developed into an important trend in the power industry not only in the field of power supply to individual (primarily remote) users but also in the area of developing large power installations which operate concurrently with traditional power plants.

We should note that nontraditional power engineering has not been developing smoothly but was characterized by its rises and falls. In the mid-Seventies, many economists predicted its unusually rapid development and an increase in the contribution of the nontraditional energy resources to our total energy balance of up to several dozen percentage points by the end of the century. Yet a more sober view based on a balanced approach and assessment of both fossil fuel reserves and realistic economic indicators of the power plants based on nontraditional energy resources gradually gave way to this euphoria. This was due to taking into account such negative aspects of nontraditional energy sources as the impossibility of transporting and storing them, irregular supplies, and low energy density. All this puts a damper on a wide-ranging spread of nontraditional power plants and does not make it possible fully to meet the energy needs even in the regions with the best supply of such energy resources.

Nevertheless, utilization of nontraditional renewable energy sources is continuing to expand, more and more countries and companies are entering this sphere, international cooperation is growing, and production of new equipment is rising. The principal driving force for this today is probably not the depletion of fossil fuel reserves or their cost but concern about air pollution in large cities, acid rain, global warming, the hazards of nuclear power, flooding of large areas resulting from hydroelectric power plant construction on great plain rivers, etc. At the same time, purely energy-related factors, of course, are also at work, e.g., fossil fuel savings and the possibility of developing fully self-sufficient power supply sources in remote and isolated regions.

Yet the purpose of this article is not to review or analyze the status of nontraditional power engineering in the world but to attempt to identify the reasons of our country's noticeable lag in this field which may probably help us to find ways of resolving the existing situation.

At first, I would like to mention the following. Until a certain time, the former USSR occupied the leading role in the development of nontraditional power plants. Back in 1970, a 100-kW wind power plant--the first such unit in the world--was built in Crimea. Low-capacity wind power generating units were built on a mass scale in the Forties and Fifties. We were the fourth country in the world which built a geothermal power plant and the first one which carried out experiments involving new methods of utilizing geothermal heat transfer agents and low-potential heat for generating electric power (the total flow method and the method of utilizing low-boiling substances in the second circuit). Back in the Twenties, Academician V.A. Obruchev proposed a concept of utilizing the heat stored in the rock; it was subsequently developed in the work of such prominent scientists as A.N. Shcherban, Yu.D. Dyadkin, and others. The possibility of utilizing the heat of the Earth's depth without bringing the steam and thermal springs to the surface was mentioned by Nobel laureates Academicians N.N. Semenov and P.L. Kapitsa. Up until the mid-Eighties, we remained leaders in thermal water production. The concept of tower-type solar power plant development was also proposed for the first time in our country. The work of our scientists in the field of photoelectricity has been recognized throughout the world, and the first photovoltaic solar arrays for space purposes were also developed here. We are the second country in the world which built a tidal electrical power plant, thus implementing the floating construction method which has gained wide acceptance among all hydraulic engineers in the world.

Yet today's situation with nontraditional power engineering in Russia is very discouraging. Our sole 11-MW geothermal power plant places us between the 20th and 30th place in the world, production of PV arrays amounts approximately 1% of world production, only one type of wind power plants with a 4-kW output is being mass produced, and these are vastly inferior to their foreign counterparts.

So what is the problem? Why, after achieving noticeable success in basic research and at the stage of pilot prototype and model development, we eventually are entering the period of stagnation or even decline?

One can attempt to identify a number of factors which, to a certain extent, would explain this phenomenon.

First, the system of manifestly centralized power and total planning is, by its very nature, poorly suitable for setting up distributed or small-scale production. It could develop a powerful missile industry or Sayany-Shushenskoye hydroelectric power plant, but it is incapable of setting up production of high-quality consumer goods. This requires a developed sense of the market which, to a large extent, is typical of independent companies rather than state structures.

The second factor is an artificial system of prices which differs significantly from world practices. The exceptionally low fuel and energy prices, compared to world levels and to prices for other products in our country, have created far-from-favorable conditions for the development of alternative energy sources. This factor was especially powerful in rural areas where preferential

fuel and energy prices led to the rejection of any proposals to implement power plants on the basis of nontraditional renewable energy sources.

The breakup of the USSR seriously aggravated the disastrous conditions in Russia's nontraditional power engineering. Let us examine how things stand by looking at its principal areas today.

Solar power industry. Two of the three principal centers producing solar collectors for heat supply--Tbilisi and Sumgait--ended up in foreign countries. The third one, located in Bratsk, has, in essence, ceased production and completely switched to traditional heating equipment. The solar collector market which began successfully developing in the southern republics of the former USSR did not gain a foothold in Russia, although both economic estimates and foreign experience confirmed the expediency of their application over most of the Russian territory. Most of the organizations engaged in activities to improve the solar collector designs and production methods, developing solar heat supply systems, and examining the likely demand and possible utilization trends of this equipment also ended up beyond Russia's boundaries. These include Spetsgelioteplomontazh which probably achieved most success in disseminating and implementing solar heat supply systems and plants, the Solntse Scientific Production Association of the Kiev Zonal Scientific Research and Planning Institute of Standard and Experimental Design, and many others. The Power Engineering Institute imeni Krzhizhanovskiy has lost its Alushta base specifically designed for research in the field of solar heat supply. A building with solar power supply which was used by the High-Temperature Institute at the Academy of Sciences for Research is in Armenia, etc.

The only solar power plant in the former USSR, the SES-5, is in Crimea; it was expected that an extensive solar power engineering program would be implemented there. Construction of a solar power plant using parabolic cylindrical concentrators was also anticipated there. This is a new trend in the field of solar power utilization which is extensively developing abroad.

Ashkhabad and Yerevan are home to large branches of the All-Russian Scientific Research Institute of Fuel Utilization (VNIIT) which has been carrying out a large scope of efforts to develop photoelectric solar energy converters. The program of scientific and applied research into photoelectricity was recently scratched, maybe somewhat prematurely, from the work plan of the head organization of the Kvant Scientific Production Association in Moscow. When this was being done, it was expected that these efforts would be concentrated in the aforementioned department and the Saturn Scientific Production Association located in Krasnodar. As a result, a large team of highly skilled experts who did not want to move to Krasnodar and are now attempting to implement the efforts in photoelectric power engineering at the All-Russian Institute of Rural and Agricultural Electrification left the Kvant association but the institute does not have the necessary production base for this purpose. The resolutions adopted at the highest levels for setting up production of photoelectric cells and modules in Tashkent and Krasnodar for eventual use for civilian purposes remained ignored.

Geothermal power engineering has also fallen on hard times. Since 1963, the Gas Industry Ministry has been in charge of geothermal resource utilization. It was also in charge of geothermal power engineering financing and logistics. The activities of the Burgazgeoterm Directorate, which had a small share of combined Gas Industry Ministry activities, also did not attract serious attention of industry leaders. Yet the directorate existed while geothermal power engineering was

developing, albeit insufficiently, primarily due to Mingazprom sponsorship. The economic mechanism which would be capable of ensuring independent development of geothermal power engineering was, in essence, poorly set up and was hardly feasible under the existing conditions. There are probably two main reasons for this--the low profitability of the extracting enterprises due to the clearly deflated price for thermal waters (which was set without taking into account the thermal potential) and preferential financing of geological exploration efforts from the state budget--compared to the funding for operating the deposit.

Today, the situation is even more complicated. First, this year the Gazprom concern removed geothermal power engineering from the sphere of its interest and second, pursuant to the "Law of Mineral Wealth," geological exploration is to be financed from the state budget only during the so-called exploratory assessment phase, yet as we know, the scope of efforts during this phase does not make it possible to confirm the reserves. The practices which existed until this year assumed financial participation of the thermal water user only after the reserves are confirmed by the State Commission in Mineral Resources (GKZ), yet this can be done on the basis of operational drilling after developing the deposit. Today, the customer has to pay for detailed prospecting, although he is still not psychologically prepared for it. In accordance with the Law of Mineral Resources, the very concept of centralized financing calls for developing an off-budget mineral raw material resource restoration fund formed by payments for mineral resource utilization. Most of this fund will remain in place and, allowing for the insignificant geothermal power engineering contribution to the regional energy balance, one cannot expect a noticeable volume of investment in geological exploration activities on the part of the local authorities.

As a result, the Burgazgeoterm Directorate found itself in a difficult situation since it has drilled numerous holes in many areas, yet the wells are not ready for operation, while financing has essentially run out. The Gazprom concern, in turn, abandoned all work on geothermal deposits, as a result of which, Burgazgeoterm is threatened with liquidation.

Wind power engineering. There are also serious difficulties with wind power plant development. Several years ago, interest in them was spreading rapidly. The wind power plant (VEU) power range measures from several dozen watts to 1 MW or higher. Large plants were expected to be developed at defense enterprises--the Raduga Moscow Design Office, Yuzhnoye Scientific Production Association, and Production Association of the Leningrad Transport and Hoisting Machinery (Lenpodyemtransmash). A number of organizations and cooperatives were attempting to master production of small wind power plants. These included small enterprises at the Moscow Aviation Institute and Central Aerodynamics Institute, Aleksandrovskiy Mechanical Engineering Plant, and Moscow Heat Power Engineering Institute as well as the Paraplan and Sinteks cooperatives, Tochnost, Azimut, and Energiya scientific production associations, etc., yet the political and economic transformation occurring in the country has noticeably complicated and slowed down this process. The Yuzhnoye Scientific Production Association located in Dnepropetrovsk is now abroad. The sites selected for the first two wind power plants--Crimean and Dzhungar--are located in the Crimea and Kazakhstan. As a result, it became necessary to search for a new site and develop a new project. Yet its implementation is running into considerable, primarily financial, difficulties.

A similar situation characterizes the development of other nontraditional renewable energy sources--organic waste, small water stream energy, and low-potential heat from the environment.

We should also mention the development of experimental bases and certification centers. The latter are required, first, to protect the users from poor-quality products and thus prevent negligent producers from discrediting the very concept of nontraditional renewable energy source utilization, and second, to identify the trends of subsequent equipment improvements. Many such centers exist abroad but none can be found in Russia. So far, there is only one GOST standard for solar collectors and just one test bench for testing them. With respect to experimental bases, we have already mentioned that both the Alushta base and SES-5, which were treated primarily as a test range for various types of equipment and operating conditions, are now under Ukrainian jurisdiction. Having lost these as well as the prospect of setting up a special base in the Sudak region, the Russian Federation Ministry of Fuel and Energy made the decision to build a test range in Dagestan in the area of the Chirkeyskaia hydroelectric power plant. This construction was included in the list of installations financed by the federal budget, yet not a single ruble has been received thus far. Moreover, concern has again been expressed about the worsening inter-ethnic conflict in the Northern Caucasus.

The breakup of the USSR and the freeing of prices for a number of goods, resources, and services radically changed the entire economic mechanism. Runaway inflation, unpredictable and uneven increases in prices, and disrupted economic links seriously complicate forecasts of the development in any industry of the economy and make it almost impossible for the branches which have not played a decisive role in the national economy. Nevertheless, it is necessary to attempt to make such forecasts and predict the general trends so as to minimize the likelihood of errors in today's difficult times and, possibly, ensure a better future position for the country in the world market.

First of all, I would like to note that any new endeavor, as a rule, is started by enthusiasts and is based on faith in its success. By this I am not trying to say that we do not need economic analyses or feasibility studies for implementing various concepts. Needless to say, all this is needed, especially in carrying out the specific designs, yet conviction should always underlie everything. Without it, neither the airplane nor the steam engine would have been invented. History teaches that Napoleon lost the war at sea only because he did not believe in the steamboat.

I am not going to cite the economic estimates of nontraditional power engineering installations. They are too numerous, and we can always select the ones we are most comfortable with. Yet it would be worthwhile to mention, e.g., the fact that today, the cost of electric power production at Pauzhetskaya geothermal power plant is lower than that of fuel oil heat and power supply stations in the town of Petropavlovsk-Kamchatskiy. One should also note that U.S. Public Law No. 488 of 15 Jun 83 regulates the economic indicators of power plants utilizing nontraditional renewable energy sources. Implementation of a special program was stipulated for achieving these indicators by 1995. In particular, the aforementioned law sets the cost of energy generated by wind power plants: it should amount to no more than 3-5 c/kWh while specific capital outlays for wind power plants should not exceed \$500-700/kW. Specific capital outlays for PV converters should not exceed \$800/kW, while the cost of solar heat supply should not exceed \$36/Gcal.

If these indicators are achieved, nontraditional power engineering will not only fill its niche in power supply for specific users but will also seriously compete with traditional power plants in the broadest field of power supply.

I would like, nonetheless, to advise caution in comparing the economic indicators of different types of power plants. Thus, the cost of 1 kW energy produced by a pocket battery is several thousand times higher than the same kilowatt-hour from the wall outlet, yet the batteries are still scarce, and no one is going to abandon them. After all, when you are going to the woods, you cannot bring the wall outlet with you. One should be equally as cautious in comparing the specific capital outlays: 1 kW of installed capacity of a unit running on wind energy or solar energy is very different from 1 kW from a traditional power plant, since in the former case, this power is neither peak power nor rated power and cannot be realized at a random time period. It is also not easy to take into account fuel shortages or delivery problems. By foregoing such a detailed analysis of the economic competitiveness of nontraditional power engineering in this article, we relied on the accumulated world experience and assumed that there was a niche for which nontraditional power engineering was not only suitable but also economically expedient; therefore, we shall indicate only the measures which may ensure its successful development.

This, first of all, is state support. In many countries which have achieved noticeable success in developing nontraditional power engineering, the state provided considerable assistance. This included state financing of special programs and legislation which establish tax and credit benefits for nontraditional power engineering installation producers and users. As a result of these laws, in many cases it was profitable to acquire such units and sell the power generated by them to state or private companies while buying power from existing utilities for housekeeping requirements. As a result, the corresponding market appeared and developed quickly which, in turn, forced the producers to improve their products. As the cost of energy generated by these plants decreased, benefits were gradually reduced or eliminated altogether.

Perhaps such measures are especially necessary in today's Russia since due to the breakup of the USSR, we were forced to resolve many issues from scratch, and any long-term project looks unattractive against the backdrop of runaway inflation. An overwhelming majority of enterprises and companies are forced to work under the conditions of a struggle for survival, and in their activities, they are guided by the desire to realize profit as quickly as possible. Yet nontraditional power engineering requires a certain learning curve for achieving the necessary technical level and setting up mass production.

Unfortunately, the measures taken today by the state in this area not only facilitate resolution of the negative factors which prevent the development of the nontraditional power industry but rather make them chronic. As a result of the large number of diverse programs related to nontraditional power engineering in one way or another, the resources are spread thin, and serious results cannot be achieved. These programs include the "Environmentally Clean Power Engineering" State Scientific Technical Program (GNTS), the conversion program, the agroindustrial complex program, branch-wide scientific-technical programs of the Russian Federation Ministry of Fuel and Energy, etc. Virtually all of these contain individual proposals which are not connected to each other by a unified purpose and, in essence, ensure survival of selected entities. On the other hand, the largest projects, such as the Mutnovskaya geothermal power plant or Kalmyk wind power plant, whose implementation could radically affect progress in this sphere of power engineering, have not been supported with sufficient resources (the federal budget did not call for financing them) as a result of which these construction projects are turning into white elephants which discredit their own concept. We should also note several statewide measures which negatively affect the development of nontraditional power engineering. In addition to the

low prices of fuel and energy as well as unreasonable benefits for consumption. in rural areas. there is another problem: considerable economic distortions have developed as a result of holding down prices for the fuel and energy resources. on the one hand. and freeing prices for other types of products. on the other. The prices of materials and equipment have increased at a much faster pace than the prices of fuel and energy. so today. it is simply unprofitable to save fuel and energy by implementing new installations or methods. Furthermore. the correlation of prices of fuel and electric power (converted to the same measurement unit). compared to foreign prices. is clearly distorted due to the relatively low cost of fuel.

Nevertheless. the problem of developing and mastering nontraditional renewable energy sources requires its own solution since if today we deprive nontraditional power engineering of state support. we will not only doom ourselves to lagging hopelessly behind the advanced countries. but we will also ruin existing enterprises which have dedicated themselves to the noble task of developing the environmentally clean power industry on the basis of renewable energy sources and will scatter and destroy the material and technical base already developed.

Nontraditional Power Engineering in Market Economy

947F0170C Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 12, Dec 93 pp 15-18

[Article by V.I. Savin, RAO of the Russian Consolidated Power System]

[Text] The use of nontraditional renewable energy sources (NVIE) became more widespread in the late 1970s and 1980s, and this power engineering trend acquired a greater significance: this was the period when the economies of the capitalist countries witnessed the formation of a more developed (mature) market which was characterized by saturated demand and the emergence and activation of a new subject of market controls--organized user demand, an increase in the flexibility of production and consumption relationships, and decentralization of economic power, both on the scale of national economies and within individual corporations, as well as enhanced competition.

Under such conditions, the state scientific and technical policy in the field of nontraditional renewable energy sources development and assimilation was formulated a result of analyzing the options and making decisions in two key areas:

direct economic regulation by means of organization and direct financing of equipment and technology production and development on the basis of nontraditional renewable energy sources, setting up priorities, and budget allocation among various branches of science as well as financing of research and development carried out by state scientific centers; and

indirect economic controls--stimulating the development of science and implementation of scientific accomplishment in the private sector with the help of the tax, depreciation, patent, and foreign trade policy and by maintaining the necessary level of competition.

Due to the large scale and duration of R&D, basic research, and developments in the field of nontraditional power engineering, the state assumed a considerable proportion of their financing at the national level and at the level of international cooperation (approximately 50%).

In addition to implementing national programs, most industrially developed capitalist countries are actively participating in carrying out programs of various international organizations and communities: the International Energy Agency, the common market, and the Association of Nordic Countries.

Among the indirect methods of exerting economic pressure on the development of nontraditional power engineering, the following were used at the equipment production and marketing phase:

partial subsidies from the equipment producer and buyer budget, beneficial credits and low-interest loans for the development and implementation of power plants on the basis of nontraditional renewable energy sources:

beneficial credit repayment terms for buyers of electric power generating systems on the basis of nontraditional renewable energy sources and beneficial accounting terms for users of electric power generated with the help of nontraditional renewable energy sources; and

tax holidays for companies and private individuals acquiring nontraditional power engineering equipment.

A number of EEC member-countries, the United States, and Japan have implemented various R&D programs in the field of nontraditional power engineering on the basis of various forms of state incentives and brought many practices to the stage of commercial and industrial applications.

In recent years, considerable changes have occurred in the field of state policies of these countries toward stimulating the nontraditional power engineering development. New trends have appeared in the forms and methods of state financial incentives which can be summarized by the following:

an increasing role of indirect stimulation methods:

a selective, goal-oriented type of assistance:

an increase in appropriations for applied research and innovation:

an increasing role of credits and the use of contractual bank credits on beneficial terms:

an introduction of tax and other benefits in the field of environmentally "clean" technology development and implementation of energy-saving types of equipment as well as tax holidays for users of nontraditional renewable energy sources:

an increase in the scope of various forms of assistance to medium-sized and small companies:

the development of forms of state cooperation with private business, including contractual relationships as well as joint research; and

incentives in the field of venture capital.

The following type of sanctions are used for environmental pollution: fines, compensatory withholdings, and additional taxes or funds. Insurance from pollution risk is an important element in the field of environmental protection.

The processes which employ solar, wind, and geothermal energy, and in some countries, the biomass energy, have developed into priority nontraditional renewable energy source implementation trends.

The U.S. Department of Energy allocated \$836.3 billion in 1993 for R&D in the field of nontraditional power engineering development and for increasing the utilization efficiency of fossil fuels (\$34.9 billion was spent in 1990). In the Federal Republic of Germany, the Federal Research and Technology Ministry allocated 318 billion marks for efforts on nontraditional renewable energy source utilization and energy conservation in 1991 and 279 million marks in 1992. Funding of such activities is also on the increase in Spain (150 million pesetas during the 1989-1995 period), Italy, Austria, and other countries.

Development of a new state policy aimed at creating a constant incentive for innovation and enterprise is underway in all countries with a developed market economy.

One of the state functions today is to maintain competitiveness of corporations and firms both on the domestic and world markets. The specific forms and methods of industrial state control differ greatly, yet all of these pertain to the field of direct regulation. State subsidies and loans on beneficial terms are given for construction of nontraditional power plants and implementation of new methods. Subsidies take up more than 50% of all budget expenditures allocated for the development and mastering of nontraditional renewable energy sources.

Production of power plants on the basis of nontraditional renewable energy sources may also be simulated by providing low-interest or interest-free, long-term credits. Low-interest credits for capital construction, overhaul, and design work in this field make it possible to start up or expand production of materials, equipment and systems utilizing nontraditional renewable energy sources. It is also possible to provide long-term bank credits for these purposes on favorable terms.

Tax benefits are aimed at commercial development of energy production technologies using renewable sources. Thus, U.S. Congress approved the following tax benefits for the period extending to 1995 (as a percentage of total installation costs):

Residential building units:

solar and geothermal	20
wind power	5

Units for industrial entities or trade enterprises:

solar, geothermal, wind-power, and bioenergy	10
thermal gradient	5

Financial incentives programs exist in a number of countries. Thus, pursuant to the federal energy-efficient building construction program in the territory of the Schleswig-Holstein land in the Federal Republic of Germany, heat recuperation is promoted by a ten-year tax reduction. In Berlin, taxes for using nontraditional renewable energy sources are reduced up to 60%, while the government of the Northern Rhein-Westphalia land amortizes up to 25% of the cost of units utilizing nontraditional renewable energy sources.

The tax policy also involves certain tax cuts for the prospecting, development, and exploration of nontraditional renewable energy sources. Furthermore, in a number of countries (the United States and Italy), scientific research and development in the field of nontraditional power engineering are stimulated by legislative and regulatory decrees.

The development of the nontraditional power industry in the USSR was regulated by resolutions of regulatory bodies which treated nontraditional renewable energy sources as an important reserve of the traditional fuel economy.

Here, an approach to nontraditional power engineering as a state problem was crystallized in 1986 after the approval of "Measures to Increase the Utilization of Nontraditional Energy Sources in the National Economy During 1987-1990."

In 1990, the Russian Federation Ministry of Science switched to competitive-basis R&D financing of individual projects aimed at developing pilot models of nontraditional power engineering equipment.

As a result of the low technical, process, and production base level, virtually no tested highly efficient equipment ready for commercial implementation exists for any of the nontraditional energy sources. This considerable lagging behind foreign developments is due to a number of reasons and some unsolved issues which reflect both the general problems in our economy and the specific problems for each type of nontraditional power engineering; the following can be identified among these:

- a lack of economic incentives for using installations utilizing nontraditional renewable energy sources among both producers and consumers;

- a poor development of the system of economic incentives of the users employing nontraditional renewable energy sources;

- a lack of goal-oriented financing and inefficient utilization of the resources allocated;

- a weak (or to be more precise, virtually nonexistent) mechanical engineering base for producing modern process equipment for nontraditional power engineering;

- the existence of barriers among industries and a lack of coordination among the enterprises which manufacture new equipment utilizing nontraditional renewable energy sources;

- a lack of well-developed economic relations among potential users of nontraditional power engineering installations and economic organizations which support the fabrication, comprehensive delivery, assembly, and operation of the units;

- a low technical level and high capital-to-output ratio of the mass-produced equipment and installations for the nontraditional power industry; and

- a virtual lack of R&D coordination, fracturing of efforts in the field of nontraditional power engineering, and a lack of a single coordinating center for scientific and application research.

The breakup of the USSR deprived the Russian Federation of a number of bases which had been developed as test ranges for various types of nontraditional power engineering equipment. Thus, two of the three principal solar collector production centers for heat supply purposes (in the cities of Tbilisi and Sumgait) ended up in the near abroad. The same happened to most of the organi-

zations which were developing solar heat supply systems and developing and improving the solar collector design and production methods and organizations involved in wide-ranging projects in the field of photoelectricity.

The Yuzhnoye Scientific Production Association in Dnepropetrovsk as well as the sites selected for two wind power plants--Crimean and Dzhungar--are also now in the near abroad.

A similar situation exists in the field of organic agricultural production waste utilization. Bio-energy plants, one of which (in Pärnu, Estonia) was the largest in the former USSR and was developed by the Estonian Collective Farm Design Institute based on recommendation of the State Scientific Research and Development Institute of Agriculture (Moscow), are in the Baltics and Ukraine.

Today, nontraditional power engineering in the Russian Federation is in the scientific research and exploratory development stage, while only several units are actually being utilized.

Under the developing market conditions, a new mechanism is necessary for controlling the development of nontraditional power engineering, including several key moments:

determining priority trends in nontraditional renewable energy source development;

selecting and providing state management and economic support to priority trends in nontraditional power engineering; and

tracking and correcting the socioeconomic and environmental conditions.

No country in the world can develop its economic mechanism of nontraditional renewable energy source utilization on the basis of a single management method. A comprehensive approach which includes such diverse control methods as economic, legal, administrative, and information dissemination is dominant.

In summing up the above, we can identify the following organizational and economic measures which stimulate the development of nontraditional renewable energy sources:

1. Setting up a coordinating center (group) of nontraditional power engineering at a government level (the Russian Federation Economic Industry or Russian Federation Ministry of Fuel and Energy).
2. Introducing the institution of independent expert examination which would make a stage-by-stage assessment of the priority trends in nontraditional renewable energy sources development and make recommendations for the necessary adjustments of the initial strategy.
3. Adopting legislative decrees which stimulate the development of nontraditional power engineering.
4. Formulating a program for the development and utilization of nontraditional renewable energy sources financed from state budget funds.

5. Developing a system of state incentive measures aimed at increasing the scale of production and application of equipment and plants utilizing nontraditional renewable energy sources: the latter should include the following:

allocating state budget funds for R&D in order to develop nontraditional renewable energy source projects selected on a competitive basis as well as those important for the national economy:

applying a system of benefits in the framework of a consolidated taxation system, including a decrease (up to 10%) of profit withholdings into the state budget for the organizations which implement utilization of nontraditional renewable energy sources:

extending the benefits stipulated for the enterprises which manufacture consumer goods to the production and application of nontraditional power engineering units intended for individual use or utilized by a group of users for the purpose of improving social and environmental conditions:

providing favorable credits for the production and acquisition of equipment and nontraditional power engineering units: in so doing, it is necessary to formulate the conditions for extending and repaying loans for the purchase of individual installations and equipment:

providing benefits for the purchase of imported equipment:

compensating for the part of the equipment cost from state budgets or dedicated funds:

providing target-oriented financing to the enterprises which manufacture nontraditional renewable energy source-based installations during the production assimilation phase:

allocating state grants for implementation of solar heat supply systems, bioenergy plants, and heat pumps as well as for ensuring loss-free organic waste utilization plants amounting to 30-50% of the cost of equipment:

developing a favorable pricing policy for energy-related production (hot water, heat, and electric power) from self-contained power plants running on local renewable energy resources and reimbursing the users for each substituted kilowatt-hour: and

developing regulatory documents which govern the relationships among the owners of individual power plants and power systems and which set terms for clearing accounts for the energy supplied and consumed.

6. Developing a market of nontraditional power engineering equipment produced on a share capital basis with a share participation of the manufacturing plants and future buyers.

7. Setting up new market-type structures--territorial marketing or dealer centers.

8. In allocating centrally distributed quotas and funds for the fuel and energy resources, taking into account the savings of all these resources due to nontraditional renewable energy source utilization amounting to one-half of the savings realized during the preceding period.

9. Providing state support for various brokerage and cooperative organizations involved in dissemination and implementation of nontraditional renewable energy source-based plants.
10. Setting up international economic and scientific and technical cooperation in the field of nontraditional renewable energy source utilization.
11. Training staff and organizing seminars as well as assessing the equipment efficiency, assimilating and developing computer systems, etc., in order to support implementation of the results of R&D in the field of nontraditional power engineering.
12. Advertising and disseminating information about the nontraditional power engineering methods, including military industrial complex plants, developing a system of databases and data banks on domestic and foreign developments and mass production of equipment which utilizes nontraditional renewable energy sources; and compiling catalogs and organizing exhibits and seminars in this field and getting the military industrial complex involved in this activity.

Recommendations of Scientific-Technical Conference on 'Nontraditional Power Engineering: Problems and Development Outlook'

947F0170D Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 12. Dec 93 pp 29-30

[Article by conference participants]

[Text] 1. General Nontraditional Power Engineering Development Aspects

1.1. Nontraditional power engineering should be regarded as an important individual direction of scientific and engineering progress in the industry and an important energy conservation trend.

It should be recommended that the Institutes of the RAO of the Russian Consolidated Power System and Russia's Academy of Sciences clarify the power industry development concept which, in addition to centralizing electric and thermal power production management and concentrating capacities at large fossil-fuel, hydroelectric, and nuclear power plants, should provide for wide-ranging development of decentralized power engineering on the basis of nontraditional renewable energy sources.

1.2. It should be regarded expedient for the regional joint stock companies of electrical power engineering, scientific research and design institutes in the industry, and academies of science of CIS member countries and agroindustrial complex enterprises and local authorities to step up efforts of justifying the scale of nontraditional renewable energy source utilization in various regions in order to determine the technical policy and economic development conditions of this important power industry trend and ensure support to the development of original nontraditional power engineering development programs.

1.3. The fastest possible development of highly efficient and reliable environmentally clean equipment for the nontraditional power industry and steps to ensure the conditions for its wide-ranging implementation should be regarded as an especially important scientific, engineering, social, and economic task. Involvement of defense-related branches of industry in the framework of conversion is important in achieving success in the development of such equipment.

1.4. It is necessary to note the important role played by the State Scientific-Technical Program of "Environmentally Clean Power Industry" being implemented through financing from the state budget funds and off-budget ministry funds in the development of new nontraditional power engineering equipment. A request should be made to the Russian Federation Ministry of Science, Russian Federation Ministry of Fuel and Energy, and RAO of the Russian Consolidated Power System to provide for the possibility of expanding the program by means of new promising developments and by eliminating from it all projects which have proven to be inefficient.

1.5. To note the importance of comprehensive original programs in Karelia, Dagestan, Kamchatka, Amur oblasts, and Pacific maritime and Krasnodar krais which brought on-stream geothermal, wind, and solar power plants, small hydroelectric power plants, geothermal and solar heat supply plants, and comprehensive utilization of nontraditional renewable energy sources formulated by joint stock companies (power systems) and power engineering departments for the development of nontraditional power engineering.

Recommend that such programs be expanded for the regions with a stressed fuel and energy balance and a complex environmental situation for resort and recreation zones and remote and inaccessible regions of the country.

1.6. The following tasks should be regarded as high-priority objectives for the developers of equipment, research and development organizations, joint stock companies of the RAO of the Russian Consolidated Power System, and buyers of power installations on the basis of nontraditional renewal energy sources from other ministries and departments:

practically validating in 1993-1995 the design and scientific and technical solutions using experimental and pilot power plants and units employing nontraditional renewal energy sources and developing standard unified design solutions on the types of equipment:

developing an experimental base and certification centers for nontraditional power engineering trends in Russia:

setting up efforts to develop standards and certification of new nontraditional power engineering equipment and procedures of analyzing its efficiency, etc. (for equipment buyers and developers);

ensuring that governing bodies of the republics of the Russian Federation, oblasts, and krais as well as CIS member countries participate in the formulation of regional nontraditional renewal energy source implementation programs and resolving the issues of their financing; and

providing incentives to the manufacturers and users of nontraditional power engineering and improving its competitiveness with traditional power plants by developing a system of grants and tax and other benefits.

The conference has noted that the issues of wide-ranging implementation of nontraditional power plants and electric power stations calls for active participation of mass media and the entire population.

Successful development of nontraditional power engineering cannot be ensured without developing high-priority economic conditions for implementing the formulated programs and measures at all stages of scientific research and exploratory development efforts and practical utilization of nontraditional renewal energy sources.

(The remainders of paragraphs 2-7 provide detailed recommendations for all nontraditional power engineering trends).

8. Support, Economic Incentive, and Benefit Measures Aimed at Nontraditional Power Engineering Development.

8.1. We consider it necessary that at the initial implementation phase of the new equipment based on nontraditional renewal energy source utilization, measures be formulated to provide economic incentives to the users and manufacturing enterprises in the development, fabrication, implementation, and utilization of nontraditional power engineering equipment, and to request that the Russian Federation Government consider the possibility of doing the following:

allocating state grants to the users of equipment, either mass produced or under experimental or commercial pilot production; and

providing low-interest, long-term credits.

8.2. The RAO of the Russian Consolidated Power System should prepare proposals for the Russian Federation legislative bodies on the systems of benefits for nontraditional renewal energy source utilization in the framework of a unified taxation system which provides for lowering the tax on profits and temporarily suspending value-added tax withholdings from the activities in the field of nontraditional renewal energy source utilization and from the new facilities and equipment developed in the process.

8.3. The central and regional energy commissions should be requested that when they consider and approve electric power rates, they provide for measures which stimulate the development of ecologically clean installations on the basis nontraditional renewal energy sources. The development of environmentally clean power plants and electric power stations on the basis of nontraditional renewal energy sources should be regarded as an important component of environmental protection measures and plans.

8.4. Keeping in mind the considerably smaller scope and time frame of the efforts than those in traditional power engineering and allowing for the need for accelerated implementation of nontraditional renewal energy source-based equipment and energy conservation technologies, we should consider the possibility of recommending that the buyers finance the development of nontraditional power engineering installations using working drawings and individual estimates all the way to the completion of the development project and design approval.

8.5. In preparing power industry and energy conservation legislation, we deem it necessary to determine the organizational structure of energy conservation activities and the corresponding organization of nontraditional renewal energy source utilization as a whole in the country as well as in various regions. RAO of the Russian Consolidated Power System should prepare and submit relevant proposals to the government.

9. Management Measures to Speed up the Nontraditional Power Engineering Development.

9.1. The conference has noted the importance of maintaining and continuing joint activities of CIS member countries in the field of nontraditional technology development and energy saving plants in the electrical power industry.

9.2. In the opinion of the conference, development and implementation of comprehensive regional programs encompassing extensive utilization of nontraditional renewal energy sources for all self-contained power engineering installations, primarily for the Kubanenergo, Sibirenergo, Stavropol-energo, Dagestenergo, Rostovenergo, Kamchatskenergo, Sakhalinenergo as well as for the Arctic, the Baltic Sea, and Gulf of Finland coast, and Baykal and other regions is necessary for the development of nontraditional power engineering.

9.3. The conference is appealing to the local authorities in all republics of the Russian Federation, krais and oblasts and the population and public entities with a request to participate actively in setting up nontraditional renewal energy source development activities, searching for the necessary resources, and creating favorable conditions for expanding the use of nontraditional methods, renewal energy sources, and energy-saving processes and installations.

9.4. The conference is appealing to the leaders and teams, institutes, and design offices of generating equipment-making enterprises, especially the defense branches of the industry involved in the efforts to master nontraditional renewal energy sources and conserve energy in the framework of conversion and request that the development of efficient equipment for nontraditional renewal energy source utilization and energy conservation be regarded as an important task of uplifting the national economy: it calls on providing more initiative and ensuring the fastest possible development and assimilation of mass production of technically complex and highly efficient equipment for solar, wind power, geothermal, and tidal power plants, small and microscopic hydroelectric power plants, etc.

9.5. The conference participants noted that the issues of the development and operation of nontraditional power plants and conversion of nontraditional power engineering into a large-scale branch of the power industry call for active cooperation on the part of the mass media and the entire population.

9.6. The conference organizing committee should be charged with preparing an appeal to the Russian Federation legislature and government with proposals on the measures of economic support to nontraditional power engineering, including tax benefits and centralized financing for the most important installations.

9.7. The conference regards the following measures as expedient:

carry out scientific and technical conferences on the issues of the nontraditional electric power engineering development every two years and solicit participation of foreign experts:

ask that the Siberian Electric Power Industry Department consider the possibility of carrying out the next meeting in 1995 in the Siberian region; and

recommend that annual seminars and symposia be conducted on the nontraditional power engineering development trends.

9.8. The conference is requesting that the organizational committee publish the proceedings of the plenary sessions and information about the section meetings in periodicals and scientific and technical industry journals.

On Wind Power Plants

947F0172A Donetsk AKTSENT in Russian No Unknown, 8 Jul 94 p 1

[Article by P. Osipenko]

[Text] Retiree Ye.N. Dotsenko from Krasnoarmeysk wrote to us asking: "In an article describing environmental problems, your paper recently mentioned power plants utilizing the energy of the wind saying that such stations could be profitably built in Donbass where there are many windy days per year, so is anyone addressing this issue?"

This question can be best answered by the resolution recently adopted by the Ukrainian Cabinet of Ministers (No. 415 of 15 Jun 94) "On Construction of Wind Power Plants." In particular, the resolution states that in order to facilitate wide-ranging implementation of renewable energy sources and more efficient utilization of production capacities under the Ministry of Machine Building and Military Industrial Complex and Conversion, the Economic Ministry and Energy and Electrification Ministry must structure the electric power rates so as to ensure that 0.5% of the volume of marketable electric power production is accumulated by the Energy Ministry in a dedicated account for the purpose of building wind power plants in various regions of the country and expanding the production capacities of wind power engineering equipment.

With respect to the foregoing, the Ministry of Machine Building and Military Industrial Complex and Conversion must prepare within one month proposals regarding export of wind power engineering equipment and the development of the necessary conditions for this endeavor.

The resolution was also signed by our countryman Ye. Zvyagilskiy. Only time will show whether or not it will prove to be workable under the new prime minister.

Kazakhstani Nontraditional Power Engineering Development Program

947F0174A Almaty ENERGETIKA I TOPLIVNYYE RESURSY KAZAKHSTANA in Russian
No 4 (6), Oct-Dec 93 pp 21-25

[Article by K.V. Omelyanenko and A.Ya. Siroka, Kazgeliobioterm Kazakhstani Solar. Biological. and Thermal Power Concern, Almaty; UDC 620.97]

[Text] The Republic of Kazakhstan has a high energy potential of nontraditional renewable energy sources (NVIE). Thus, by using only 1-1.5% of just the solar energy which shines upon the republic's territory without any detriment to the environment, one can obtain $(0.1-1.5) \cdot 10^{13}$ kWh/yr which is an equivalent of 1.2-1.8 billion tons of equivalent fuel. The predicted fossil fuel demand in the Republic of Kazakhstan in 2010 amounts to 140 million tons of equivalent fuel. Yet in today's total energy consumption in Kazakhstan, the proportion of the solar, wind, thermal water, and biomass energy is insignificant and amounts to less than 0.02%. The principal reasons arresting the development of nontraditional power engineering are as follows:

- the need for considerable financial and physical outlays at today's industrial development level;
- a weak production base in the field of nontraditional power engineering equipment; and
- the lack of a state program which would provide financial assistance to the nontraditional power engineering equipment producers and users.

The principal premises of the draft program call for for the development in the republic of the most promising solar, wind, thermal water, and biomass energy utilization trends.

The program does not encompass data on small hydroelectric power plants and wind power generating units with a capacity of more than 100 kW. The issues of small hydroelectric power plant development have been considered on numerous occasions in various articles, and no reliable analytical data are available for large wind power plants (VES).

The total fuel and energy resource (TER) savings due to implementation of the program objectives will increase by eighteenfold by 2010 compared to 1993 and will be equal to 340-350

thousand tons of equivalent fuel, while the proportion of nontraditional renewable energy sources of the total fossil fuel consumption in the republic will be equal to 0.24-0.25%. In the total fuel and energy resource savings, the solar power plant share is 26% and the wind power plant share is 21.5%, while the thermal water utilization is 51% and that of bioenergy plants--1.5%. Electric power generation due to nontraditional renewable energy source utilization will reach 26.0 thousand kWh in 1995, 117.0 thousand kWh in 2000, and 460.0 thousand kWh in 2010. The cost of activities under the program will reach on the order of 89.2 billion rubles by 2010 (in 1 Mar 93 prices), which includes 0.7 billion rubles or R&D (NIOKR) and 88.5 billion rubles for capital investment.

In assessing the aforementioned indicators, the growth rate of the nontraditional power engineering facilities and the scope of their implementation in the national economy were selected on the assumption of the existing need and anticipated demand. One should keep in mind that today, the cost of energy production from nontraditional renewable energy sources is considerably higher than that of the traditional power industry. Yet the use of today's fabrication methods of nontraditional power engineering facilities and utilization of new, cheaper materials and equipment makes it possible to lower the outlays and production costs of the energy being generated. Consequently, the program calls for a range of measures to improve the production of solar collectors and water lifting, wind power, and other units which utilize nontraditional renewable energy sources.

Successful development of the industry, especially at the initial phases, requires that financial assistance to the nontraditional power engineering facility manufacturers and users be organized at a state level. Analyses show that in order to create favorable conditions for the development of nontraditional power engineering, it is necessary that the state compensate for something on the order of 30-40% of the expenditures associated with the development of production bases and fabrication and operation of power plants which utilize nontraditional renewable energy sources. The status and development prospects for the principal types of nontraditional renewable energy sources are considered below in a generalized form.

Solar Power Engineering

Solar energy can be used extensively over two-thirds of the Kazakstani Republic territory (to the south of 50°N).

Keeping in mind that 40% of the total energy consumption is used for heating, hot water supply, and air conditioning in residential, public, and commercial buildings, solar heating and cooling installations have the highest priority for implementation in the national economy. Today, this field is the best known and most tested from the technical viewpoint. Solar water heating units may find wide-scale applications. At present, only a small number of such units is used in the republic--approximately 200 installations with a total solar receiving surface area of 5-8 thousand m². The program calls for production of solar collectors with a total surface of 12.0 thousand m² by 1995, 110 thousand m² by 2000, and 400.0 thousand m² by 2010. By 2010, solar collector output will reach 40,000 items per year. The planned implementation scope of solar water

heating units, solar building heating systems, solar dryers, and other devices will make it possible annually to save tens of thousands of tons of fuel (see Table 4). The principal technical and economic indicators of existing solar water heating units are summarized in Table 1.

Table 1: Solar Water Heating Unit Indicators

Parameter	Measurement Unit	Indicator
Mean water heating temperature	°C	55-5
Initial water temperature	°C	12-15
Daily output per 1 m ² of solar collector surface	m ³	0.08
Cost of 1 m ² of solar collector	thous. rubles	25-35
Water heater unit metal-to-output ratio	t/kWh	0.2-0.35
Cost of production of 1 m ³ of hot water	rubles	400-600
Capital outlays for 1 kW power	thous. rubles	60-90

It is expected that R&D will make it possible to develop more efficient solar water heaters which are competitive with conventional devices.

Efforts in photovoltaic plants are successfully proceeding in the developed countries despite the fact that according to expert estimates, they cannot become competitive in the near future due to considerable capital outlays for their development and production. With respect to the foregoing, the program calls for activities to develop silicon production--the principal material for PV converters and a raw material which is abundant in the republic. Exploratory efforts made it possible to assess the outlays necessary for the development of solar power engineering. The resulting findings are summarized in Table 4 (in 1 Mar 93 prices).

Wind Power Engineering

Vast wind energy resources are concentrated over the Kazakhstani Republic territory. By tapping into at least 1-2% of this potential, the national economy may annually receive on the order of 10-20 billion kWh. For comparison, we can indicate that the republic's need for electric power in 2010 will, according to forecast data, amount to 150 billion kWh. Agriculture is the principal customer of wind power plants. In expert estimates, approximately 40,000 wind-powered water lifts with an up to 4-kW each and approximately 17,000 wind power units will be necessary in the near future: these include the following: 11,000 units with an up to 4-kW power, 5,000 units with a 30-60-kW power, and 1,000 units with a 150-500-kW power.

The program provides for the development, fabrication, and implementation of wind power plants with a capacity of 0.25, 30 and 60 kW intended for power supply to self-contained users, e.g., livestock stations, farms, teams, etc. Modular generating unit power plants on the basis of these machines are capable of supplying electric power, heat, and hot water virtually to any user. Large-scale production of such wind power plants is being planned at the republic's specialized enterprise--the Karagandainterwind consortium. It is anticipated that 5,300 wind power plants will be manufactured and installed in 1993-1995 (with a capacity of 0.25 to 60 kW), 16,300 in 1996-2000, and 29,400 in 2001-2010. By 2010, there will be total of 51,000 wind power plants.

The following amounts of electric power will be generated annually by the wind power plants: 25.7 million kWh in 1995, 117.0 million kWh in 2000, and 463 million kWh in 2010. This will make it possible to ensure fuel savings. Data on outlays for the wind power engineering development until 2010 (in 1 Mar 93 prices) are summarized in Table 4 for the above figures.

Table 2: Wind Power Plant Unit Indicators

Parameter	Measurement Unit	Geyser Water Lift	AVEU-6-4M Wind Power Plant
Lifting height	m	20	-
Output	m ³ /h	1.5	-
Capacity	kW	0.4	4.0
Capital investment-to-output ratio	thous. rubles/kW	173	265
Metal-to-output ratio	kg/kW	330	300
Cost of production	ruble/kWh	-	7.8
Cost of 1 m ³ of water	rubles	8	-

The technical and economic indicators of some wind power plants are summarized in Table 2.

Geothermal Energy Utilization

The Republic of Kazakhstan is rich in geothermal water resources, yet to date, there are no data on confirmed reserves. The most promising are the geothermal resources concentrated within three artesian basins: the Almaty, Dzharkent, and Arys. These are the ones that can be utilized first in the national economy. Certain characteristics of these basins are summarized in Table 3 according to data from the All-Union Scientific Research and Development Institute of Geothermal Energy in Makhachkala.

Out of the tapped geothermal resources of 132.9 thousand m³/day, wells with a total discharge rate of 70,000 m³/day are being used sporadically mud baths, public utilities, and agriculture.

Table 3: Characteristics of Artesian Basins

Basin Name	Tapped Geothermal Resources, thous. m ³ /day	Predicted Resource Estimate, thous. m ³ /day	Temperature Potential, °C
Almaty	4.8	319.9	35-96
Dzharkent	33.4	561.7	70-80
Arys	94.7	198.9	up to 70
Total in southern Kazakhstan	132.9	1080.5	

The national economy is taking 120,000 m³/day of thermal water with a mean temperature on the order of 60.0°C from the available inventory of wells. This makes it possible to ensure fossil fuel substitution on a scale of 87,000 tons of equivalent fuel/yr. The program calls for solving a number of scientific and engineering problems on comprehensive thermal water utilization. The outlook for its use for heat and hot water supply to industrial and municipal users is good. Feasibility studies conducted to date made it possible to assess the principal impact from implementation of the thermal water utilization measures. Data on likely fuel and capital investment savings are summarized in Table 4.

Table 4: Nontraditional Power Industry Development Outlook

Nontraditional Power Industry	Fuel savings, thous. tons of equivalent fuel			Expenditures, millions of rubles			Including investments			R&D		
	1995	2000	2010	1995	2000	2010	1995	2000	2010	1995	2000	2010
Solar power engineering	2.16	25.5	87.0	493.0	3,242	6,152	406.0	3,200	6,100	87.0	42.0	52.0
Wind power engineering	5.2	15.5	31.0	3,900	16,000	52,750	3,840	15,920	5,273	60.0	80.0	20.0
Geothermal power engineering	20.0	60.0	15.0	-	-	-	310.0	720.0	1,100	-	-	-
Bioenergy engineering	-	1.7	6.2	16.5	1,285	3,150	2.0	1,050	3,150	14.5	235.0	-

The cost of heat production will be equal to 300-400 rubles/Gcal, while the capital investment-to-output ratio will be on the order of 900,000 rubles/MW. For implementing the program objectives on bringing to the national economy the heat energy of the Earth's depth, plans call for developing the dedicated enterprise which will make it possible to regularize the system of thermal water extraction and utilization, overhauls, and operational monitoring during the well operation.

Biomass Production and Biomass Energy Utilization

All efforts to utilize biomass in the Republic of Kazakhstan should primarily pursue an environmental objective. Moreover, waste elimination for the purpose of improving the environmental and sanitary and epidemiological conditions is becoming more crucial than the energy impact realized from this type of raw material.

Today, one cannot find a single commercial livestock farm manure fermentation unit in the republic. The typical reasons for this are the large capital investment required, the pay-off time, and public tolerance to environmental pollution.

The program calls for carrying out research and development aimed at processing waste, developing and fabricating pilot prototypes of farm and livestock complex manure fermentation and implementing 40 bioenergy power plants in environmentally troubled regions by 2010. Annual fuel and energy resource savings due to biogas (methane) production by these units are assessed in Table 4. Furthermore, by 2010, close to 720,000 tons of high-quality organic fertilizers will be produced. The program stipulates implementation of commercial units for growing algae (chlorella)--a valuable product which is being utilized in medicine, the food industry, and agriculture--using the resources of the Kazgeliobioterm concern. Chlorella production is profitable, and the pay-off period does not exceed two years. Outlays for the bioenergy engineering activities are summarized in Table 4.

New Wind Power Plant

947F0174B Almaty ENERGETIKA I TOPLIVNYYE RESURSY KAZAKHSTANA in Russian
No 4 (6), Oct-Dec 93 pp 95-96

[Article by V.P. Orlov and A.V. Arzamastsev, Vetromashservis Wind Power Machinery Service Company, Almaty]

[Text] The AVE-30 wind power plant with a 30-kW capacity was developed and prepared for implementation by the Karagandainterwind scientific production consortium of small state enterprises (in Karaganda) together with the Vetromashservis Scientific Production Company (in Almaty). This event is an important milestone in the development of Kazakhstani wind power engineering since no power plants with such a capacity have been manufactured in the republic until now.

The wind power plant is capable of providing electric power to a small department, farm, or another installation. The modular generating unit wind power plants developed on the basis of these devices are capable of supplying power to virtually any user. It is necessary to emphasize that the term of "power supply" is understood not only as provision of electric power to an installation but also as meeting its heat and hot water demands.

The power plant under study may serve as the basis for developing the next generation of machines with a unit power on the order of 60-100 kW.

The first experimental AVE-30 wind power plant was assembled at the site of the Karaganda-interwind scientific production consortium (MPK) for powering the heating electric boiler at the concern.

Pilot demonstration tests reveal that even at a wind velocity of 4.5-5 m/s, the wind wheel develops a speed of 50 rpm and a power of 5 kW, while at 7.5- 8 m/s, its power reaches 9.6 kW vs. the design capacity of 9 kW. At a 10 m/s wind velocity, the wind power plant reaches its design capacity of 30 kW. The wind power plant performance indicators measured during the tests are consistent with the design values.

Today, the Karagandainterwind scientific production concern and Vetromashservis Scientific Production Company are assembling and adjusting several machines in Kokshetau, Karaganda, and Torgay oblasts.

Performance Characteristics of AVE-30 Wind Power Plant

Power, kW	30
Wind wheel diameter, m	12
Metallic tubular tower height, m	15
Operating wind velocity range, m/s	5-25
Design wind velocity for attaining rated power, m/s	10
Number of wind wheel blades	3
Rotor rotation speed control	electrohydraulic
Wind orientation system	wind rose
Rated voltage, V	380-220
Nominal wind wheel speed, rpm	75
Generator speed, rpm	1,500
Number of phases	3
Current frequency, Hz	50 + 5
Maximum permissible wind velocity, m/s	45

Technical and economic analyses carried out by experts from the Kokshetauselstroy Agricultural Development Trust No. 2 and Vetromashservis Scientific Production Company demonstrate that when the wind power plant is connected to the company kindergarten heating circuit, the wind-driven generating machine's pay-off period is equal to 1.5 years at existing electric power rates. The profit is evident, especially since most of the Republic of Kazakhstan is characterized by the wind conditions which are favorable for the use of wind power plants as the principal source of electrical power supply to individual user groups. In a number of cases, the wind power plant can be used as a standby power source for the purpose of saving electric power and fossil fuel.

Nontraditional Power Engineering Development Problems in Kazakhstan

947F0175A Almaty ENERGETIKA I TOPLIVNYYE RESURSY KAZAKHSTANA in Russian
No 1, Jul-Sep 92 pp 115-117

[Article by B.M. Marinushkin. Karagandainterwind Consortium. Karaganda]

[Text] The approach to the development of nontraditional renewable energy sources (NVIE) as a state-wide problem crystallized by late 1988 when a program to increase the nontraditional renewable energy source utilization in the national economy in 1987-1990 was approved: it encompassed a broad range of nontraditional renewable energy sources, from solar energy sources to minihydroelectric power plants. Why do we need all this? The thrust of this program was organic fuel substitution with various types of renewable energy sources which are so plentiful in our republic.

The urgency of nontraditional renewable energy source utilization is determined not by today's scale but by the role which nontraditional power engineering will play 5-10 years from now.

Economical use of nontraditional renewable energy sources is possible today virtually in every oblast and every rayon. Nontraditional sources may provide electric lighting and heat to the persons living in the areas of decentralized electricity and heat supply (shepherds, geologists, summer home residents, field crop growers, etc.) who have experienced daily hardship with energy resource supplies. In most villages and urban settlements and towns, there is electricity but no hot water supply, and oftentimes, no central heating. In these inhabited localities, the problem of residential heating is becoming increasingly difficult to resolve. There is a high degree of likelihood that this problem could be solved with the help of nontraditional energy sources.

Nontraditional renewable energy sources are called upon to play a special role in recreation areas, range breeding pastures, and regions with stressed environmental conditions. In the next 2-3 years, it will be technically possible and economically expedient in these areas to decrease the amount of fossil fuel being burnt by up to 25-30% and lower outlays for power system construction and operation by several thousand times, thus making it possible to decrease environmental pollution and eliminate routine manual labor for a large number of people currently working in dilapidated and decrepid boiler rooms.

Livestock (especially pig-raising) farms, poultry factories, and urban dumps which pollute the surrounding soil, water, and air have become a real disaster for the residents of the nearby villages and towns. One can get rid of them using one of the types of nontraditional power

engineering--a bioenergy power plant which treats waste and processes it into high-quality fertilizer and biogas which, in turn, provides heat and electric power.

In our republic, a number of organizations, which in the past year or two have been joined by defense enterprises, are involved in nontraditional power engineering problems at the level of scientific and design activities. Today, the Karagandainterwind scientific production consortium of small state enterprises which is a part of the Kazgeliobioterm solar, biological and thermal water concern is the closest to the user (until 1990, it was the Kazakh Department of the Vetroen Scientific Production Association which today encompasses five enterprises).

Forming a concern was not just paying tribute to fashion or simply replacing the sign. Today, small state enterprises, e.g., Razvitiye, Proizvodstvo, or Vnedreniye [development, production, and implementation, respectively] ensure the entire wind power plant life cycle, from concept to assembly and servicing, which distinguishes the consortium from the former department of the Vetroen Scientific Production Association (NPO).

We should mention that in virtually one year, the Geyser wind machine unit has traversed the path from concept to implementation and large-scale production. This unit is favorably distinguished from the notorious Romashka [daisy] installation which, despite the same metal-to-output ratio, had a number of serious design flaws and very low output (under $0.3 \text{ m}^3/\text{h}$). The Geyser was the first development which turned out to be very successful. It exceeds the output of its Seiko-3 Danish counterpart by sixfold but has the same wind wheel diameter. The first tests of these wind machines were carried out at the Koktalskiy state farm where a real burst of wind energy is observed. In 1991, Geyser units were exported to Bulgaria, China, Holland, and Argentina. Good reports about their performance have been received.

The Law of the Republic of Kazakhstan "On the Priority of Aul, Village, and Agroindustrial Complex Development" formulated the objective of supplying agriculture with all types of self-contained energy sources on the basis of nontraditional sources. The development and utilization of these types of machines could significantly accelerate implementation of the Resolution by the Karaganda Oblast Council of People's Deputies No. 439/91 of 4 Oct 90 "On Accelerating the Connection of Shepherd Winter Abodes to the State Electrical Network" and decrease its cost. Implementation of electric power supply from the state electrical network will require millions of rubles in investment and will not solve the problem of heating and hot water supply, i.e., comfortable living conditions. Yet self-contained, wind-sun-diesel systems will be cheaper by two orders of magnitude, and the issues of the shepherd way of life will be resolved several times faster.

The question is often asked of how timely was the formation of the Karagandainterwind scientific production concern enterprise? It is perhaps the most modern and promising among today's enterprises.

Western countries, e.g., Denmark, today cover up to 20-25% of their total energy demand by renewable energy sources. In the former USSR, it was only 0.2% in 1990, while in the Republic of Kazakhstan, this figure is negligible. And this in a vast territory where the wind energy is estimated to be 2-4 billion kWh/yr!

The energy shortfall in Karaganda oblast reaches 300 MW today, yet construction of many kilometers of electric power transmission lines for providing lighting to winter abodes and powering a 1.5-4 kW pump which provides water to livestock farmers is still continuing. Outlays for generating and transmitting 1 kW of electric power received from the state regional power plant (GRES) and from a wind-driven generating unit are not even comparable. At the same time, to our great embarrassment, no one does anything to measure the health of the population, while the environmental conditions can best describe not life but struggle for survival. So is this endeavor timely? From the viewpoint of the spirit and morale--yes! The team is involved in meeting the needs of off-line users, developing a medium-power energy source (30-60 kW), and, in cooperation with defense enterprises, is mastering the first domestic machine with a 250-kW capacity and in the near future--a generating unit with a unit power of 500 kW. For the first time in the history of wind-generating unit utilization, combined machines which can both lift water and generate electric power were developed jointly with the Harbin Electrical Engineering Institute. These developments take into account the needs of the shepherds, summer home residents, geologists, and other self-contained users.

Unfortunately, the Karagandainterwind scientific production concern was also "up to date" in the prices of its products. Yes, the price liberalization, the rapid increase in the prices of energy sources, and the pressure of taxation forced an increase in the price of its products. When speaking today about the cost of wind power plants, one should also keep in mind the cost of the metal and the cost of 1 kWh. By the way, at today's level of prices, the wind-driven generating unit is paid off 2.5 times faster than would have been the case last year, prior to the price liberalization. There is a simple example: On any state farm, there are winter breeding pastures where water is delivered by road. Let us assume that today, the cost of one vehicle-shift is equal to 1,000 rubles in round figures. Thirty vehicle-shifts are necessary every month, i.e., water delivery would cost 30,000 rubles. Yet a generating unit costs less than 10,000.

Under the conditions of a market economy or, to be more precise, economic chaos, the staff of the Karagandainterwind scientific production concern is experiencing the same, if not greater, difficulties as other enterprises. The burden of taxes is just as heavy, yet financing for new developments is provided from the profits generated by its own small enterprises. All appeals to the oblast council and oblast executive committee in 1991 remained unanswered, although the "Law of the Aul Development Priority..." stipulated that these activities be financed from the oblast and republic budget. Today, research into the development and production of nontraditional power engineering equipment (wind, sun, and biogas) is supported almost entirely by enthusiasts. The centralized program was not implemented in the USSR and there is no similar program in the Republic of Kazakhstan nor is there anything similar in the oblast.

Under the conditions of decentralizing industrial management, enterprises of the Karagandainterwind scientific production concern are continuing to develop and fabricate equipment. The activity has not been shut down, but it has to be rescued. What has to be done? First of all, to determine the likely extent of state support to the development and organization of nontraditional power engineering equipment production at the level of oblast administration and republican government. According to estimates, this will require 8-10 million rubles in the next 5 years. These resources must form an innovation fund for nontraditional power engineering. Outlays for financing and setting up production must be recovered as profits are derived from equipment

implementation. This is the only way of overcoming the existing situation where no one wants to pay for development yet is prepared to pay any money for off-the-shelf equipment.

In addition to centralized financing, the following types of economic assistance must be established:

- state payments for 30 to 50% of the cost of equipment (the figures are 80% in the United States, 50% in the Federal Republic of Germany, and 70% in Denmark) intended for operation in rural settlements, private plots, and farms;
- a system of tax benefits for equipment users and manufacturers (value-added tax);
- a decrease in the tax on the profits derived from the development, pilot batch manufacture, and implementation in rural areas;
- measures to enable the enterprises to sell the fuel they save in commodity exchanges; and
- financial incentives for the enterprises as a whole and individual persons who operate the nontraditional power plants.

Such approaches to nontraditional energy sources will make it possible to organize thorough efforts to substitute fossil fuels, reduce environmental pollution, and solve a number of social problems in a short period of time.

Development of the Wind Energy of Dzhungarian Gate

947F0176A Almaty ENERGETIKA I TOPLIVNYYE RESURSY KAZAKHSTANA in Russian No 3, 1993 pp 62-69

[Article by service chief, Cand Tech Sci M. N. Kambarov, and engineer, patent scientist G. S. Suleymenova, Almatyenergo and the Institute of Mechanics and Mathematics, Almaty; UDC 621.5]

[Text] Dzhungarian Gate [Dzhungarskiye Vorota] in the southeastern part of the Republic of Kazakhstan is one of the windy regions of the CIS that offer good prospects for acquisition of energy by ecologically favorable means. This is a mountain pass 10-12 km wide at its narrowest point and up to 80 km long. Practically all of its territory (over 900 km²) is located in Kazakhstan (Figure 1).

The south side of the pass is steep (up to 3,500 m), while the opposite side is gentler. The pass joins the vast Balkhash-Alakol depression (hundreds of thousands of square kilometers in area) to a similar one in China. The ranges separating them, Dzhungarskiy Alatau and Dzhair, form natural barriers oriented from southwest to northeast, 400 and 250 km long respectively. Thus nature created something akin to a natural wind tunnel in the passage between them. In the cold part of the year, winds blow through Dzhungarian Gate alternately in a northwestern and southeastern direction: "yevgey" and "saykan." These are among rare and interesting examples of orographic wind intensification. An international railroad operates over this pass, and a 100 kV electric power transmission line is being built through it. There are all possibilities here for building a system of wind power generating units (VES) of high unit output.

As of the moment only one weather station is functioning at Dzhungarian Gate--Zhalanashkol (since 1961). The wind conditions of the past cannot be correctly evaluated on the basis of data from the two stations that worked in different periods of time--Dzhungaria (1956-1961) and Druzhba (1956-1969). A meticulous study of inhomogeneities in the wind velocity field within this region is currently being conducted at the request of Almatyenergo. Such research is extremely important when it comes to selecting the optimum location of wind power generating units and building the corresponding wind power plants (VEU).

A site of around 65-80 km² several kilometers northwest of the railroad station at Zhalanashkol may be said to be the most representative today for construction of VES.

Figure 2 shows the mean monthly wind velocities for a 10-year period of observations, and recurrence of winds of different intensities, according to materials of this weather station. According to data of the Kazakh Scientific Research Institute of Power Engineering the relative energy of the wind flow at an altitude of 10 m above the ground at Dzhungarian Gate is 17.8 MW·hr/m². Inasmuch as the velocity required to set wind power plants currently existing in the world into motion begins as a rule at 5 m/sec, it may be asserted that

the VES will produce practically no energy in the three summer months. This correlates acceptably with the electric power demand, especially if we consider that the VES will operate in parallel with the Almatyenergo power system, which also runs hydroelectric power plants.

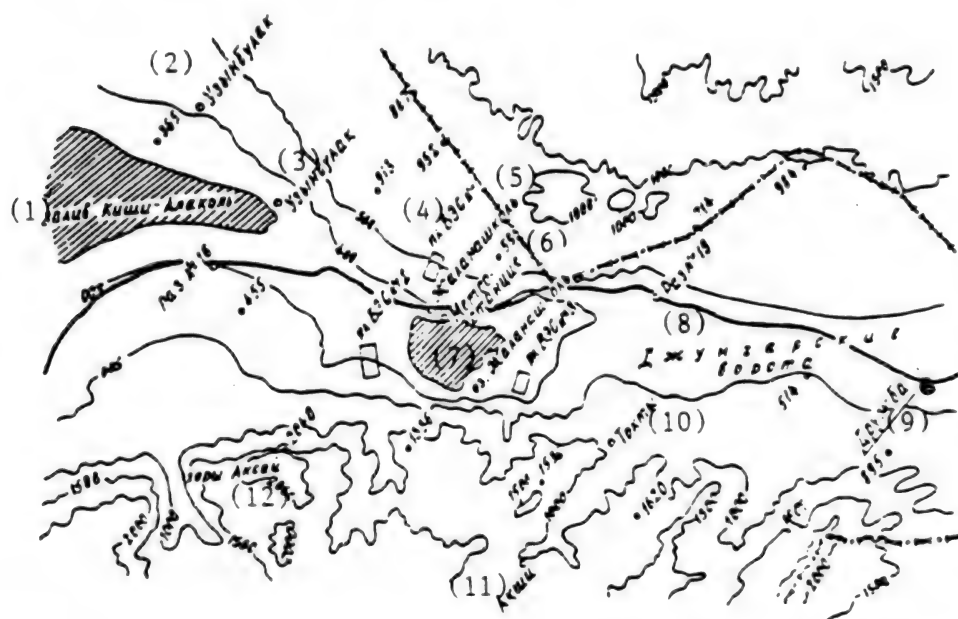


Figure 1. Map of Dzhungarian Gate

Key:

- | | |
|---------------------|----------------------|
| 1. Kishi-Alakol Bay | 7. Lake Zhalanashkol |
| 2. Uzynbulak | 8. Dzhungarian Gate |
| 3. Uzynbulak | 9. Druzhba |
| 4. VES site №... | 10. Tokty |
| 5. Zhalanashkol | 11. Akshi |
| 6. Weather station | 12. Aksay |

As is evident from the wind energy potential indicators presented here, the choice of VES for the indicated conditions is far from clear. The table presents the characteristics of several types VEU and their possible effectiveness when used under the wind regime of Dzhungarian Gate.

As is evident from these data, the proportion of usefully employed energy increases with growth of unit power of the VEU.

However, there are a number of factors preventing use of the indicated general-purpose VEU, which consist of a tower, a gondola and aerodynamic blades communicating with energy converters (the classical type of VEU).

Intensive migration of birds from the Eurasian part of the CIS to China and India and back occurs through Dzhungarian Gate. This will obviously make it necessary to sharply reduce output and the number of hours of operation of VEU during the spring and fall migration seasons.

The pass is devoid of forests, it is practically uninhabited, the soil is rocky, and therefore wind velocities at an altitude of 10 m and higher do not differ strongly. In this case the wind rose consists for practical purposes of two vectors of opposite direction ("yevgey" and "saykan" winds), which is very significant to the type of VEU selected. The last two factors may result in

significant underutilization of the height of the tower and the rotating gondola device. Reduction of tower height would conflict with the need for increasing the unit power of the VEU--that is, the diameter of the surface swept by the blades.

Sample Indicators of Different VEU for the Zhalanashkol Site

Type VEU	Nominal Power, Kw	Output, MW·hr/year	Wind Potential Utilization, %	VEU Manufacturing Country
56-11	100	250	7.1	USA
DANWIN	200	470	5.7	Denmark
MWT-250	250	820	7.5	Japan
ET-500	500	2050	10.8	Germany

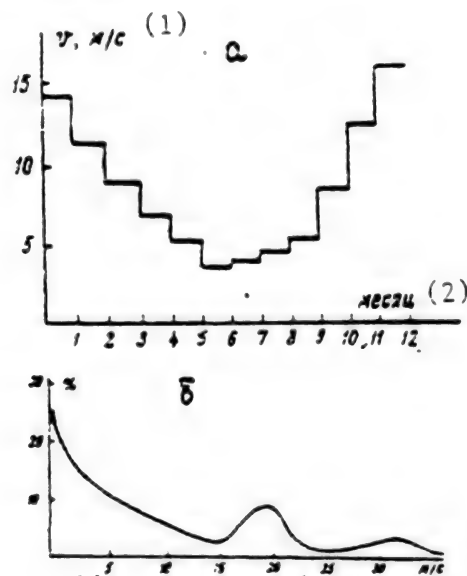


Figure 2. Characteristics of Dzhungarian Gate Wind Regime: a) mean monthly wind velocities; b) recurrence of wind velocities

Key:

1. m/sec
2. Month

Considering the unique nature of the wind energy potential of Dzhungarian Gate, and presence of a very large uninhabited territory, which is to be developed over the course several decades, the VEU must account for the limiting factors indicated above. Consequently special VEU adapted to the conditions of Dzhungarian Gate are required. Technical proposals and ideas for designing such VEU for winds blowing in a single direction presently exist. They have been offered by the Scientific Research Center of Gidroyekt, the VNIIG [not further identified] imeni V. Ye. Vedeneyev, Almatyenergo and KazIPKenergo [not further

identified). All of them account for the unique features of Dzhungarian Gate in principle. However, as with any engineering initiatives, they require a large volume of scientific research and development, experimental industrial models and sufficient time. Only after all of these stages are completed can feasibility comparisons be made among them. Even so, the great shortage of energy in the power system compels us to seek the means of fastest possible introduction of wind power generating units made up of wind power plants of proven and perfected design.

Besides the choice of VEU suited to the conditions of Dzhungarian Gate, we will examine some other technical and economic aspects that will necessarily have to be considered.

1. Connecting Wind Power Generating Units to the Power System

As was noted above, operation of a VES within the composition of a power system is the preferable variant of its operation. However, orienting themselves on this particular design case, the developers of specialized general-purpose VEU based themselves on the assumption that VES would be connected to buses of constant voltage and frequency, to a so-called "infinite-power bus." This condition is hardly observed at Dzhungarian Gate, at least in the initial stages of its development. The distance to the nearest energy sources of sufficiently large output--the Kapchagayskaya GES in the south (with sustained output of 360 MW) and the Shulbinskaya GES in the north (with sustained output of 600 MW)--is approximately 600 km, and consequently weak 110 kV radial networks extend to the Dzhungarian Gate region from Almatyenergo and Altayenergo (Figure 3). Short-circuit power is equal to approximately 10 MV·A. In this case--and this is extremely important--the frequencies of the indicated networks are asynchronous relative to each other. Thus, the Almaty power system is part of the Central Asian Unified Power System, which operates independently from the CIS Unified Power System, and Altayenergo is a part of the latter. In view of the zonal nature of the networks, voltage regulation is a problem in the Dzhungarian Gate vicinity today--that is, the region is experiencing a great deficiency of reactive power as well.

The power system nearest to the VES site is the Xinjiangenergo (China), but it also has its own, now a third, asynchronous frequency, and long zonal networks. Given the shortage of reactive power in the region, the VES must in principle produce power for weak networks in three sectors at three asynchronous frequencies. Moreover it would be extremely desirable for mutual exchange of power among the three indicated power systems through buses of the VES system. As we can see, the conditions for connecting the VES to the power systems are not simple.

A structural diagram of connection of the VES to the three indicated power systems with asynchronous frequencies is shown in Figure 4. The system consists of a direct-current link with one rectifier and three inverters (equal to the number of sectors to which power is supplied). As we know, the inverters can operate in rectifier mode, and then power exchange between the power systems can be provided for through direct current buses. In this scheme, in order to provide the needed reactive power to the direct-current link, the VEU (making up the VES) must be equipped with synchronous generators, and each inverter must be supplied by supplementary reactive power sources.

However, this scheme for transferring the power of the VES at Dzhungarian Gate can be accomplished only in the future, after sufficiently strong development of the VES, and on the condition that the unified power system of northern Kazakhstan and the unified power system of Central Asia are also united by way of the direct-current link or a direct-current line extending along the western shore of Lake Balkhash. The latter has not yet been approved for certain, and this issue is presently under discussion. When the indicated unified power

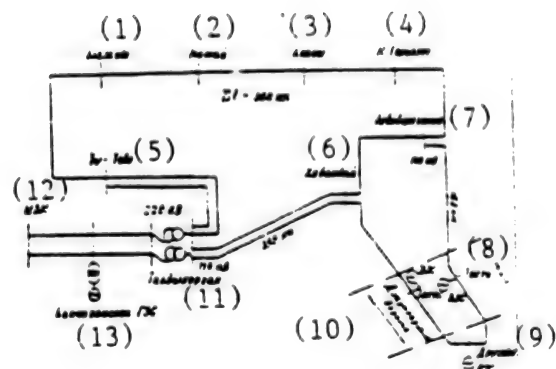


Figure 3. Diagram of the Region's Electric Power Network. Key: 1--[illegible]; 2--Matay; 3--Lepsy; 4--im. Gorkogo; 5--Ush-Tobe; 6--[illegible]; 7--[illegible]; 8--Tokty; 9--Druzhba; 10--Dzhungarian Gate; 11--Taldykorgan; 12--infinite-power bus; 13--Kapchagayskaya GES

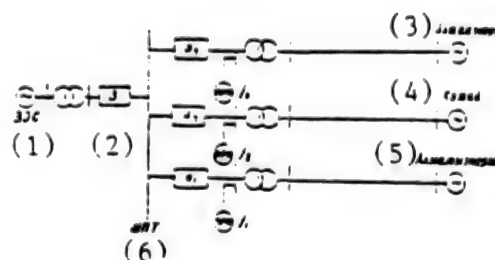


Figure 4. Diagram Showing Connection of the VES to Three Power Systems. Key: 1--VES; 2--rectifier; 3--Altayenergo; 4--China; 5--Almatyenergo; 6--direct-current bus

systems are united by means of a high-power alternating-current link (1,150 kV), as shown in Figure 4, frequencies f_1 and f_2 become synchronous, and inverters π_1 and π_2 combine. Nonetheless, in our opinion the VES still has to be connected to the two power systems through a direct-current link. First of all, the direct-current link connecting to inverter π_2 is absolutely necessary (for interstate exchange of electric power with China), and secondly, the circuit is relatively simple, and it may be supplemented by a second inverter ($\pi_1 + \pi_2$) without major capital outlays.

In the variants of schemes employing direct-current links examined here, the synchronous generators of the VES would be insensitive to the conditions of their stable synchronous operation. And this is a great advantage to VEU, because under the conditions of the existing networks of the Dzhungarian Gate region, maintenance of the stability of VEU is, as will be shown below, a rather serious problem. Thus, the initial stages of construction and development of the VES must proceed on the basis of a strategy under which the scheme by which it is connected to the three power systems as output capacities are introduced in subsequent stages of development of the wind power generating unit (group of units) and as higher power generation values are attained would be one of those indicated above. In order to explain how this strategy can be implemented, we will demonstrate the tactics of introducing VEU in the initial and subsequent stages of development of the VES.

For this purpose we will first dwell on the characteristics of the VEU from the standpoint of the electromechanical energy converters with which they are equipped. At present, high-output VEU (producing hundreds of kW per unit) manufactured by American, Japanese, Danish and German firms that are already operating within VES systems are outfitted primarily with asynchronous generators, while the ET-500 VEU is even supplied with two-speed asynchronous generators (1,000 and 1,500 rpm) in order to reduce the wind velocity needed to place the wind power plants in motion. VES systems consisting of the indicated wind power plants are operating with infinite-power buses, such that the problem of providing for reactive power is nonexistent. In our opinion VEU developers in

the CIS countries haven't yet arrived at a clear position regarding installation of electromechanical energy converters, since the market demand for their VEU has not been determined for certain. They will most likely be oriented on self-contained operation. We will examine the conditions of operation of VEU equipped with different types of electromechanical energy converters in the network conditions existing in the Dzhungarian Gate region.

2. Wind Power Plants With Synchronous Generators

Such VEU would be fully satisfactory for the Dzhungarian Gate VES in all stages of its development, inasmuch as synchronous generators produce both active and reactive power. In the final stage, as was shown above, synchronous generators are the most preferable, but they would operate unstably in the initial stages (in the absence of a direct-current link). Operating conditions would be especially dangerous at winds providing for output of a VEU that is on the order of nominal, accompanied by short-term wind gusts to 30 percent, which increase the mechanical output of the VES by 2.2 times (in proportion to the cube of wind velocity). On the other hand systems that regulate the blades of the VEU to adjust for wind gusts are unable to raise output to nominal. Thus, calculations of the stability of VES equipped with AVE-100/250 ("Vetroen") units containing GSS-104-B synchronous generators (for which the overall constant of mechanical inertia is 12.5 sec) revealed a low level of dynamic stability in the indicated conditions. Figure 5 shows the pattern of the transitional process of these VEU in the presence of wind gusts.

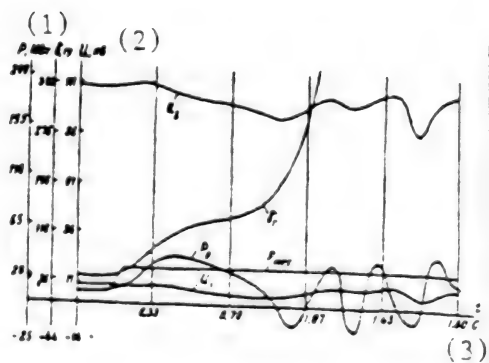


Figure 5

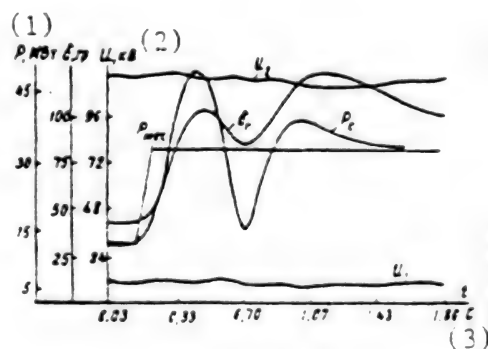


Figure 6

Key: 1--MW; 2--kV; 3--sec

In order to ensure stable operation, synchronous generators of VEU must be equipped with automatic strong-action excitation regulators (ARV-SD) (Figure 6). However, their cost is many times greater than the cost of just the generators of low-output VEU. High-output synchronous generators (100-500 MW) are usually equipped with the indicated ARV-SD.

However, one ARV-SD could in principle support the work of a large group of VEU with synchronous generators--that is, two or three ARV-SD could be installed in a VES consisting of several hundred VEU. In this case a pair of conductors would be connected to the excitation winding of the synchronous generator of each VEU from the direct-current buses of the thyristor exciter of the ARV-SD; group (unit) excitation regulation is accomplished as a result. If there are m rows of n VEU in the wind power generating unit, the VEU farthest away would

have the lowest excitation current due to growth of the resistance of the pair of conductors, which would make an identical degree of regulation impossible, and consequently the stability of the synchronous generators would vary--that is, the problem of accommodating for the internal instability of the VES would arise.

This may be surmounted rather easily by distributing the excitation current in a series-parallel scheme, as shown in Figure 7.

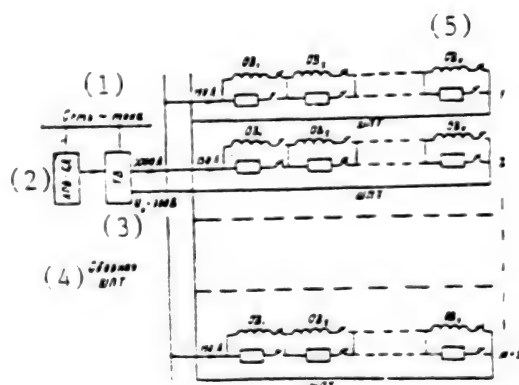


Figure 7. Diagram of Grouped Regulation of Excitation of VEU Synchronous Generators. Key: 1--alternating-current network; 2--ARV-SD; 3--thyristor exciter; 4--composite direct-current bus; 5--excitation winding

Here each row of VEU is connected to a direct-current bus, which powers the series-connected excitation windings of the generators of the VEU in this row (n units). By selecting appropriate cross-sections of the buses S_1, \dots, S_m , we can arrive at a resistance such that practically identical voltage would be fed to a group consisting of n excitation windings. If anyone of the VEU is not working, resistance equal to the resistance of the excitation winding is connected in place of it into the series-connected segment. As we know, an ARV-SD greatly raises the stability of synchronous generators, which is possible to achieve not only in the presence of wind gusts but also at a k.z. [not further identified; loading factor?] near that of the high-voltage buses of the VES. As calculations show, 200 VEU ($n = 10, m = 20$) with 500 kW synchronous generators can be supported by an ARV-SD equipped with a TGV-300 thyristor self-excitation turbogenerator. It should be emphasized specially here that the duration of wind gusts is stochastic, and in order to ensure stability of synchronous generators under the design conditions, when the blades of the VEU are producing nominal power, the excitation boosting multiple must be within 2-2.5 times the nominal current. The duration of such a state ranges up to around 10 seconds. Thus both the excitation winding and the stator winding of the synchronous generator would be overloaded for short periods of time. Therefore the VEU must be equipped with synchronous generators having a nominal output that is 1.3-1.5 times higher than the design nominal output provided by the wind wheel.

3. Operation of Wind Power Generating Units Equipped With Wind Power Plants Possessing Asynchronous Generators and Supplying a Single Power System

In this case the VES must contain additional sources of reactive power commensurate with the output of the VES. When it comes to the reactive power source, in our opinion preference should be given to synchronous compensators over

static capacitor banks. As we know, the latter have a negative controlling effect with respect to voltage, which does not contribute to stable operation of asynchronous generators. Besides that, when the operating conditions of wind power plants vary in relation to active power (in proportion to the cube of wind velocity) and to consumption of reactive power correspondingly, static capacitor banks must allow for adjustment of their output. First of all, this would occur in stepped fashion, and second, achieving such adjustments would require a larger quantity of switching units carrying out a large number of switching operations automatically. Synchronous compensators supplied with automatic excitation regulators are fully devoid of these shortcomings.

There are plans for outfitting some VEU with double-action asynchronous generators. These are asynchronous generators with a phased rotor, and they are equipped with controllable direct-current links in the rotor circuits. The latter are connected through a transformer parallel with the stator (for example the Yuzhanka-1250). Their use at Dzhungarian Gate would make it necessary to solve the problem of suppressing the highest current harmonics in the 50-250 Hz spectrum. The latter depend on wind conditions (slipping of the rotor of the asynchronous generator), and consequently the filters for the highest harmonics of each VEU or in the VES as a whole would have to be subjected to continuous retuning.

Equipping VEU with asynchronized synchronous generators with two excitation windings positioned on two mutually perpendicular axes has been proposed. In principle, these excitation windings could be supplied by the same circuit as the synchronous generator shown above. This will naturally require double the amount of equipment. Clear advantages over synchronous generators are not as yet evident.

Thus, orienting ourselves on the final stage of development of the VES at Dzhungarian Gate according to the scheme shown in Figure 4 making use of a direct-current link, and keeping in mind the operating features of the electro-mechanical energy converters of the VEU examined above, we need to develop the tactics for the initial and subsequent stages of development of the VES. In this case the scheme of development of the VES from one stage to the next (as the output of the VES increases and the networks of the power system develop) should naturally undergo transformation, such as to make maximum use of the power equipment employed in previous stages. According to plans of the Almatyenergo, by the year 2000 the Dzhungarian Gate region should be supplied with 220 kV lines 320 km long, supported by a 500/220 kV substation in the city of Taldykorgan; the k.e. [not further identified] output reaches 32 MV·A in this case. A VES equipped with asynchronous generators must not exceed this k.e. output, although over a period of 7 years it is possible to install VEU with an overall output of 200-300 MW.

However, in order to hasten introduction of the VES, wind power plants equipped with asynchronous generators should be used in the first stages of development, since they have been tested over many years, and perfected. Their use is possible jointly with operation of synchronous compensators. The minimum output of a synchronous compensator (at 10 kV) is 10 MV·A. The VES will require two sections of buses, and consequently two synchronous compensators. Thus the first-stage VES should not exceed an output of 25-30 MW. In the second stage the VES must be outfitted with wind power plants equipped with synchronous generators, and output should be increased to 100-200 MW, while the synchronous compensators could be reconnected to the inverters of the first of the direct-current links (most likely the one connecting to China), as per Figure 8.

One of the 220 kV links coming from Almatyenergo should appear on the scene by this time. After this, work can begin on a second inverter (connecting to the Almatyenergo), which must be introduced synchronously with appearance of the 200 kV link. By this time the situation regarding the unified power system of northern Kazakhstan and the unified power system of Central Asia, and conse-

quently the question as to the need for a link connecting to the Altayenergo, will sort itself out.

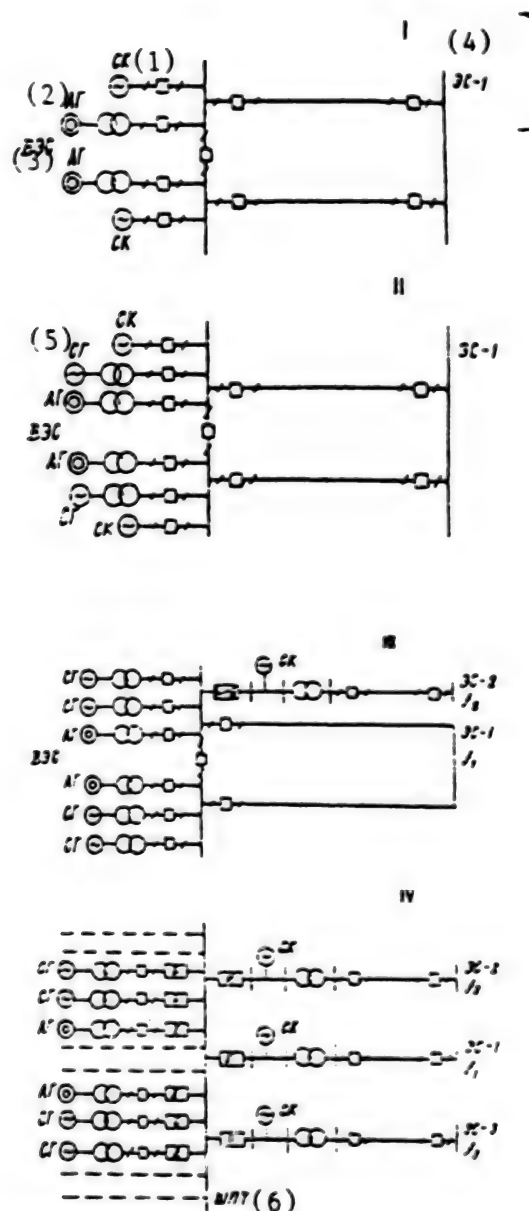


Figure 8. Stages of Development of VES. Key: 1--synchronous compensator; 2--asynchronous generator; 3--VES; 4--power system; 5--synchronous generator; 6--direct-current bus

Conclusions

1. Construction of wind power generating units is becoming competitive with traditional energy sources under currently evolving fuel and energy market conditions.

2. In view of the specific features of the wind power potential of Dzhungarian Gate, a specialized wind power plant adapted to these conditions must be developed and designed.

3. Construction of a wind power generating unit in the Dzhungarian Gate vicinity will require stage-by-stage development, with use of wind power plants equipped with asynchronous generators in combination with synchronous compensators in the first stage. In the second stage of development, wind power plants with synchronous generators having an overall output that is three to four times greater than that of wind power plants equipped with asynchronous generators would be required.

4. The wind power plants must be equipped with synchronous generators with nominal output that is 1.3-1.5 times greater than the nominal output of the wind wheel.

5. In order to ensure stable operation of synchronous generators, they must be supplied with grouped ARV-SD.

6. In the last stage of development of the VES, a direct-current link equipped with a number of inverters equal to the number of sectors of power output must be used in order to permit output of power in three (two) sectors (asynchronous frequencies), to permit emergency mutual transfers of power through high-voltage buses of the VES, and to maintain the stability of the VES.

Some Aspects of Nontraditional Power Engineering

947F0177A Almaty ENERGETIKA I TOPLIVNYYE RESURSY KAZAKHSTANA in Russian No 2, 1993 pp 78-84

[Article by director, Dr Phys-Math Sci E. G. Boos, and Cand Phys-Math Sci A. M. Voronin, Institute of High-Energy Physics, Almaty; UDC 620.9]

[Text] Development of nontraditional power engineering is an inherent part of world scientific and technical progress. The former USSR was a country that supplied itself with all of the fuel and energy it needed out of its own natural resources, using traditional forms of fuel, and it also exported sizable amounts of fuel and energy with little care for the ecological state of any given region. For example in a single year (1986) the Ekibastuzskaya GRES-1 dumped 1,281,000 tonnes of ash, 177,000 tonnes of sulfuric anhydride and 48 tonnes of nitric oxides into the air, contaminating an area on the order of 5,000 km². The harm done to nature by the work of such a power plant is equivalent to cost of the fuel, and sometimes even more. Each year the CIS releases around 70 million tonnes of dust and toxic gases into the sky. The problem of protecting the environment from pollution could obviously be solved to some degree, but this is associated with significant additional energy outlays, and the corresponding monetary outlays.

Increasingly greater attention is being devoted in the world to using renewable nontraditional sources of energy. Solution of the problems associated with their use requires meticulous analysis of world experience over the past years, and of the contemporary directions of improving energy conversion procedures and protection of the environment. Government decrees directed at intensifying efforts to develop nontraditional energy sources were adopted in the 1980s. In particular 195,000 tef [tonnes of equivalent fuel] were to be saved in Kazakhstan in 1990 in accordance with the Energy Program of the former Union through the use of renewable energy resources, to include 90,000 tef due to solar energy, 85,000 tef due to the energy of geothermal water, and 20,000 tef due to biomass energy.

Renewable energy sources are recognized to be an important component of the fuel and energy balance in most countries, and they are considered in the development of multifaceted programs of power engineering development. Besides the undoubted advantages--practical inexhaustibility and in many cases guaranteed ecological safety--these energy sources have a number of shortcomings: dispersal of reserves, the need for major capital investments, and the long period of their return. Nonetheless, measures to practically develop renewable energy sources in industry, agriculture, medicine and other spheres are developing intensively.

A comparative analysis of some forms of traditional and nontraditional power engineering will be made from different aspects below.

We will examine solar power engineering, which is classified as a so-called renewable or nontraditional energy source, the resources of which do not depend on human activity. The sun is the most powerful of all energy sources accessible to man. The power of solar radiation is great, and it is estimated at a value of $4 \cdot 10^{14}$ billion Kw. This amount is distributed isotropically in space, and only 1.4 kW of solar radiation reach a 1 m^2 area of ground surface oriented perpendicular to the sun's rays. But even this energy does not reach the ground surface directly, because it is reflected and absorbed in the atmosphere. It is believed that an average of around 0.16 kW of solar radiation reach 1 m^2 of land and ocean on Earth. Consequently solar radiation reaching the entire surface of the Earth is estimated at an amount close to 10^5 billion kW. This figure probably exceeds by many thousands of times the energy demand of mankind not only today but also in the future.

The ways of utilizing solar energy are of course extremely diverse: Throughout the existence of mankind, solar rays were used in different ways depending on the society's level of development and on the technical possibilities possessed by mankind. We can presently classify the entire diversity of means of utilizing solar energy as follows:

- indirect use of the energy of solar rays without any kind of transformation into other forms of energy;
- conversion of solar energy into other forms of energy, followed by utilization of the converted energy depending on its consumption.

Conversion of solar energy into other forms of energy may be broken down in turn into four basic directions--thermotechnical, photoelectric, photochemical, photobiological [1].

Various plans for creating orbiting power plants (space-based solar electric power plants) in which different variants of transmission of energy to Earth are possible appeared in the last two decades [2,3]. The variant in which a plant is placed in geosynchronous orbit and a photoelectric means of energy conversion is employed, combined with transmission of energy to the Earth's surface by a microwave channel, is believed to be the most suitable. The possibility of creating a system consisting of 60 power producing satellites with relative output of 5 GW equipped with solar batteries of two modifications--silicon-based and those based on gallium and aluminum arsenide--is being examined in a DOB-NASA [not further identified] project [4]. The last variant uses solar energy concentrators with a concentration degree of 2. Calculations of economic effectiveness show that given an operating life of 30 years for a space-based solar power plant, the time of full recoupment of outlays to cover the commercial cost of electric power and the cost of transportation and of producing the solar batteries would be 1-6 years. Some questions remain unclear in the proposed project: interaction of high-power microwave radiation with the Earth's ionosphere; the effect of radiation on biological objects and the electromagnetic compatibility of microwave radiation with existing navigation and communication resources. Development of measures to reduce or prevent the indicated effects must become an inherent part of work on space-based solar power plants.

The idea of space-based solar power plants seems almost in the realm of science fiction, but it is acquiring realistic outlines in our times; moreover it appears that they will be economically justified. The level of annual production of sunlight converters is not high, but even so, their cost has decreased by more than 100 times in the last 15 years. Radical improvement of the basic indicators of different kinds of photoconverters may be anticipated with the advent of large-scale industrial production--that is, when a major user, such as the space-based solar power plant, makes its appearance. Creation of such a plant would make it possible to move the principal energy production processes outside the Earth's atmosphere, it would eliminate the dependence upon imports

of fossil fuels, and it would permit development of new interstate ties in energy production and distribution.

In order to substantiate the plausibility of using solar power engineering, we need to compare different types of electric power plants in relation to the amount of land they occupy, their materials-intensiveness, and their energy return.

LAND UTILIZATION

Solar Energy

Let us examine a region in which the mean flux density of solar radiation striking a horizontal surface may be assumed to be equal to 240 W/m^2 , which corresponds to $2,100 \text{ kW}\cdot\text{year}$. In this case the flux density on the surface of motionless inclined collectors in such a region could be, with regard for diffuse radiation, 360 W/m^2 . Relative electric output of a power plant equipped with heliostats with an overall efficiency of 25 percent would be on the order of 80 MW per square kilometer of heliostat surface [5]. If all of the land occupied by the solar power plant is taken into account, this figure would decrease to 40 MW/km^2 . Having the potential for raising the reflectivity of heliostat mirrors, and for improving the efficiency of the thermal energy conversion cycle through the use of magnetohydrodynamic generators and thermionic or thermoelectronic converters as a superposed plant, we can obtain 160-180 MW of electric power from 1 km^2 of collector surface, or on the order of 90 MW from 1 km^2 of land surface occupied by the entire system.

Nuclear Energy

Only water-cooled reactors will be examined in this case. The calculations for them are more complex than in the previous case because the land required for extraction and enrichment of nuclear fuel and the area directly occupied by electric power plants, regenerating units and so on must be estimated. With regard for the territory occupied by buildings of all of the listed facilities, the relative electric output would be 240 MW/km^2 [6]. However, if we add to this area the land around the nuclear reactor, we get $60\text{-}120 \text{ MW/km}^2$.

In practice, this area will grow in the future as a transition is made to development of increasingly poorer uranium ore. It should be kept in mind that only a small part of the uranium deposits contain rich ore, and inasmuch as a ton of ore with a uranium concentration on the order of 0.01 percent can produce the same amount of energy as 1 tonne of coal, the areas devoted to mining these minerals will be approximately the same. Nor should we forget the need for processing radioactive wastes, and burying them. This also requires space, and significant amounts at that.

It stands to reason that as in the case of solar power engineering, a possibility for raising the efficiency of such systems exists here as well. It may be presumed that in the future the relative electric output of nuclear power plants will be $70\text{-}150 \text{ MW/km}^2$.

Solid Fuel

We will examine coal as an example of organic fuel. Considering the area occupied directly by mines, power plants and so on, according to available data relative electric output is 170 MW/km^2 . With regard for all land devoted to coal mining, this value decreases to 30 MW/km^2 . It stands to reason that there is an enormous difference between a mine and an open-cut coal deposit. However, the latter will dominate in the immediate future. As in the case of nucle-

ar power engineering, less-rich deposits will be developed in the future, in connection with which the area of utilized land will grow. In this case the relative electric output will be within the 30-150 MW range.

Table 1. Materials-Intensiveness of Several Energy Sources, Without Regard for Material Outlays on Energy Transport and Accumulation

Energy	Materials-Intensiveness, kg/kW			Energy Ac- cumulation Required	Scarce Materials Required
	Collector	Concrete	Metal		
Solar, converted into thermal:					
present	300-600	300	15	+	-
future	200-400	400	15	+	-
Photoelectric batteries					
present	1100	-	-	+	-
future	400	-	-	+	-
Nuclear (water-cooled reactors)	800-900	800-900	50-70	-	+
Oil		500	40	-	-
Wind (at sea)		1800	260	+	-
Geothermal		200	90	-	-
Ocean thermal energy		1800	200	-	-
Organic matter		100	30	-	-
Thermonuclear fusion		?	40	-	+

Other Energy Sources

As we know, the relative electric output of wind power plants is less than 10 MW/km² today. The land around wind-driven electric power plants must be free of structures in order to maintain the structure of wind flows. Although general agreement does not exist today regarding the required distance between wind power plants, we can adopt 10 MW/km² as the maximum relative electric output of a wind power plant [7]. Electric power generation using biomass will also be rather low. Conversion of solar energy into organic matter proceeds in nature with high efficiency, but this organic matter cannot be utilized, because the traditional approaches of converting organic mass into electric energy are characterized by an efficiency on the order of 2 percent. Thus we can anticipate that in regions with a favorable climate the relative output of this means of electric power production will reach 5 MW/km².

Naturally, land space is not needed in the use of the temperature gradients of ocean waters, and therefore we will not examine them; nor will we examine tidal energy.

It is more difficult to analyze hydroelectric power facilities. The required reservoir area varies within wide limits depending on local natural conditions. It should be considered in this case that reservoirs may also be used for other

purposes. On the whole, relative electric output of hydroelectric power plants is less than 10 MW/km².

MATERIALS-INTENSIVENESS

Table 1 provides a comparative analysis of the materials-intensiveness of different types of electric power plants.

In the analysis of organic matter as an energy source, the initial values of materials-intensiveness were adopted the same as for thermal power plants, and then increased by 50 percent, with regard for consumption of materials by the biomass growing system.

ENERGY RETURN

The problem of estimating the energy return from different energy conversion systems has recently attracted considerable attention. Rather detailed information is available in this regard for nuclear power plants. As far as solar and wind energy is concerned, difficulties arise in interpreting the calculation results. A distinction was not made between a thermal and an electric kilowatt-hour in the comparisons. In general form, the energy return from a

Table 2. Energy Return From Some Energy Sources

Energy	Energy Return
Solar	
Converted into thermal:	
present	10-20
future	30-50
Photoelectric batteries in the future	20-100
Nuclear	
present	13 ± 3
future	Less than 6
Energy from organic fossil fuels	More than 15
Wind	More than 20
Geothermal	15
Organic matter	More than 20
Ocean thermal energy	More than 10
Thermonuclear fusion	Still a question mark

system was defined as the ratio of the quantity of energy produced by the system during its life to the quantity of energy expended to produce the materials

and equipment for this system. These energy expenditures may be determined either from data on materials-intensiveness, or using the corresponding economic indicators. The values obtained in the latter case are higher as a rule, because economic indicators account for interest on capital and wages. The calculation results are shown in Table 2.

It is evident from the material above that solar power engineering is of the greatest interest to society, but for the moment it is still not very useable due to the high cost of the photoelectric converters. For the moment, use of the sun's energy for heat supply purposes is practically more achievable. This is explained by the fact that heating and hot water supply, which are low-temperature processes, may be accomplished with relatively inexpensive, simple and accessible technical resources. Contemporary experience in operating a large number of experimental industrial solar heat supply systems shows that despite the high initial outlays, even when storage batteries and supplementary energy sources are used, such devices already justify themselves economically in favorable climatic areas owing to fuel economization.

CALCULATION OF CORRECTED OUTLAYS ON ENERGY SOURCES, AND SELECTION OF THE OPTIMUM VARIANT OF NONTRADITIONAL ENERGY SOURCES

We will examine the feasibility characteristics of solar heat supply systems in comparison with conventional thermal electric power plants in greater detail. We adopt the minimum corrected outlays as the criterion of economic effectiveness in optimizing our choice of heat supply source [8]:

$$O_{cr} = E_s K + S, \quad (1)$$

where O_{cr} --corrected outlays; K --capital investments; E_s --standard coefficient of effectiveness of capital investments; S --operating expenses. Operating expenses may be subdivided into expenses depending on the amount of energy supplied--the fuel component of corrected outlays S_f , and expenses depending on sustained output by energy sources and capital investments (a component of capital outlays). In general the most important outlay elements in power production are outlays on fuel S_f , depreciation S_d , wages S_w and other expenses S_o .

Fuel outlays make up the largest proportion in the case of thermoelectric power plants:

$$O_f = P_f B = P_f B_e W_e, \quad (2)$$

where P_f --mean-weighted price of 1 tef; B --annual consumption of equivalent fuel, tonnes/year; B_e --relative consumption of fuel per kW·hr; W_e --electric power supplied, kW·hr.

Then the overall outlays with regard for economic loss due to contamination of the air basin would appear as follows in general form:

$$O_{cr} = E_s K + S_f + S_d + S_w + S_o + L, \quad (3)$$

where L is the annual economic loss resulting from contamination of the air basin and soil, rubles/year.

The amount of the corrected outlays in application to a solar heater equipped with a reserve heat source [9] has the form:

$$O_{\text{nontr}} = \frac{Q_1 - Q_{\text{use}}}{\eta Q_p^n} \cdot C_f + EF + E_s + C_{\text{rel}} F + K_r, \quad (4)$$

where Q_1 --thermal load of the facility, per year; Q_{use} --useful energy obtained by the solar heater during a season, J/year; η --efficiency of the traditional heat source; Q_p^n --heat-generating capacity of equivalent fuel, J/kg; C_f --cost of organic fuel, rubles/tonne; F --surface area of solar receivers, m^2 ; E --operating costs of solar heaters, rubles/ m^2 ; E_s --standard coefficient of the effectiveness of capital investments; C_{rel} --relative cost of the solar heater, rubles/ m^2 ; K_r --corrected outlays on reserve heat source, not counting fuel consumption outlays, rubles/year.

The essence of estimating the economic effectiveness of the compared variants entails comparing the one-time outlays on their construction and the savings of current annual outlays associated with their operation.

The following ratio is a condition of the suitability of introducing the alternative variant (in our case the solar heater):

$$O_{\text{nontr}} < O_{\text{tr}}. \quad (5)$$

The anticipated or actual economic impact from using the optimum variant is determined by the known expression:

$$O = O_{\text{tr}} - O_{\text{nontr}} = (C_{\text{tr}} + E_s K_{\text{tr}}) - (C_{\text{nontr}} + E_s K_{\text{nontr}}), \quad (6)$$

where C_{tr} and C_{nontr} are the annual costs of the two variants, and K_{tr} and K_{nontr} are the capital investments in the corresponding variants, rubles.

In view of the diversity of factors having an influence here, the problem of determining the effectiveness of introducing nontraditional energy sources is a multivariant one, both in relation to the initial data and in relation to the influence of different local conditions on the calculation results. Its solution involves the need for comparing a large quantity of variants, and it requires the use of a computer. Inasmuch as operation of solar heaters has a number of unique features, the particular variant must be chosen with regard for social and ecological factors [10]:

$$\frac{Q}{K} \geq \frac{E_s(1 - \gamma \mu_{se}) + \beta/100}{C_z + \mu_{se}}, \quad (7)$$

where Q --annual savings of organic fuel; K --capital investments into the system's construction; C_z --closing and long-range outlays on organic fuel, with regard for transportation, storage and losses in heat supply networks, rubles/tef; μ_{se} --economic evaluation of the social and ecological results, expressed per tonne of saved equivalent fuel.

Adopting 1.4-30 rubles per tonne of saved equivalent fuel is recommended as the economic evaluation of ecological results, while 3-13 rubles per tonne of saved equivalent fuel is recommended as the economic evaluation of social results (in 1990 prices). The lower evaluation is adopted when natural gas is used in traditional heat generators, and the upper evaluation is used in the case of wood.

In formula (7), γ is the relative energy-intensiveness of capital investments into construction of solar heaters, tef/ruble, and β is the annual outlays on repair and operation solar heaters, percent of capital investments.

The following criterion may be used for the preliminary calculations:

$$Q/K \geq (1.8-3.4) \cdot 10^{-3} \text{ tef/ruble.}$$

The lower value is used when substituting for traditional heat generators burning solid and liquid fuel, and the larger value is used with those burning gaseous fuel. This criterion makes it possible to establish the conditions under which plans for solar heaters are socially meaningful and economically effective. Usually in world practice, solar heat supply systems pay for themselves within 7-8 years.

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